Part

D

Section 1: Aquatic Species Conservation Plan

Aquatic Species Conservation Plan for Pacific Lumber Company's SYP/HCP Volume IV Part D

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1.1. MANAGEMENT IMPACTS ON FISH SPECIES WITHIN PL'S OWNERSHIP

Although conditions present within stream channels are partly controlled by inherent physical factors, such as gradient and confinement (Montgomery and Buffington 1993), timber management activities can affect conditions important to fish. For example, timber harvest along streams can alter the flows of LWD, sunlight, nutrients, and organic carbon into adjacent aquatic systems (Chamberlin et al. 1991; Bilby and Bisson 1992; WADNR 1994; Hartman et al. 1996). These alterations, in turn, can lead to increased air and water temperatures, channel instability, fine sediment inputs, and the loss of habitat elements (e.g., pools, side channels) important to fish (Grette 1985; Rashin and Graber 1992; Powell 1987; Holtby 1988; Ledwith 1996). Similarly, sediment inputs from roads and landslides originating in upslope harvest areas can lead to reductions in the depth and/or abundance of pools and other deep water habitats in streams, the filling of pores or interstitial spaces between individual sediment particles, and, in extreme cases, to changes in the entire structure or morphology of channels (Bjornn et al. 1977; Platts et al. 1983; WADNR 1994).

PL conducts a variety of management actions that have the potential to affect fish (Table 1). Management activities associated with commercial timber production, such as road building and harvest, have the greatest potential to affect fish because they are widespread across the ownership, and they can affect watershed processes that determine habitat and water quality conditions in streams. It is these conditions, rather than direct removal or death of individual animals, that constitutes most of the expected effect of management on fish. Accordingly, mitigation of timber harvest impacts on conditions in streams is a primary focus of the proposed HCP measures.

Specific impacts of management activities on fish are discussed below.

1.1.1. Roads

PL has an extensive road network, and will develop new roads during the term of the Plan to access different portions of their ownership. Roads are widely recognized as being among the most important sources of fine and coarse sediments in streams (e.g., Weaver and Hagans 1994; WADNR 1994). Fine sediments are produced through erosion of the active surface of non-paved roads, with erosion rates generally increasing with road size and traffic levels (WADNR 1994). Cut and fill slopes, and drainage channels from roads also serve as sites for surface erosion (Burns 1970, 1972). Regardless of the source, fine sediments from roads readily remain entrained within surface runoff, and are therefore easily transported to streams (Lloyd et al. 1987). The likelihood that sediment from roads will be delivered to streams increases with both slope, and proximity to the stream channel (Trimble and Sartz 1957).

Table 1. PL's Proposed mitigation measures to protect/improve aquatic resources.

Activity	Impact of Activity	MSHCP Measure	Expected Benefit(s) of MSHCP Measure	Detailed in Sections
Logging	Increased sediment and temperature, loss of habitat features and LWD	Channel Migration Zones (CMZ) established as bankfull channel and portion of floodplain likely to become part of channel within 50 yrs	Ensure channel remains within vegetated buffer over time.	1.2.2.1
Logging	Increased sediment and temperature, loss of habitat features, LWD and channel stability	Edge of CMZ to 30' is restricted harvest buffer (RHB) for Class I streams	Improve shading, LWD recruitment, and channel stability in and along streams	1.2.2.2
Logging	Increased sediment and temperature, loss of habitat features, LWD and channel stability	Edge of CMZ to IO' is restricted harvest buffer (RHB) buffer for Class II streams	Improve shading, LWD recruitment, and channel stability in and along streams	1.2.2.3
Logging	Increased sediment and temperature, loss of habitat features and LWD	140' Limited Entry Zone (LEZ) & 90' Selective Entry Zone (SEZ) respectively for Class I and Class II streams; Single tree harvest only, no more than once per 20 yrs; Equipment Exclusion Zone (EEZ)	Improve shading, LWD recruitment, and channel stability in and along streams	1.2.2.2 1.2.2.3
Logging	Increased sediment and loss of channel stability	Equipment Limitation Zones (ELZ) and Exclusion Zones (EEZ) for Class III streams	Improve bank stability and retention of non-commercial vegetation; Reduce sediment inputs to streams	1.2.2.4
Logging	Increased sediment and temperature, loss of habitat features and LWD	Retain all down wood in RMZ, ELZ and EEZ (RMZ=RHB & late seral)	Increase LWD stocks in streams; Provide more habitat for fish and amphibians	1.2.2.2 1.2.2.3 1.2.2.4
Logging	Increased sediment, loss of habitat features and LWD	No more than 40% volume removal per entry in late seral buffer	Reduce disturbance levels; Prevent sediment delivery to streams	1.2.2.2 1.2.2.3
Logging	Increased temperature, loss of habitat features and LWD	Minimum tree densities and sizes before and after harvest in late seral buffer	Increase LWD recruitment and canopy cover levels	1.2.2.2 1.2.2.3
Logging	Loss of habitat features and LWD	Retention > 10 trees per acre with larger than 40" DBH in late seral buffer	Retain large trees for wildlife habitat and LWD recruitment	1.2.2.2 1.2.2.3
Road use/ construction	Increased sediment, loss of habitat features, egg and invertebrate mortality	Road management plan	Decrease sediment inputs to streams from existing roads, enhance fish passage	1.2.2
Road use/ construction	Increased sediment, loss of habitat features, egg and invertebrate mortality	Storm proof all PL roads over the next 30 years	Reduce coarse and fine sediment inputs to streams	1.2.2
Road use/ construction	Increased sediment	No use of roads when turbidity of water entering Class I, 11 or III streams increases	Decrease sediment delivery to streams	1.2.2
Road use/ construction	Increased sediment	All new roads built to storm proof standards	Decrease sediment delivery to streams	1.2.2
Hillslope Management	Increased sediment	Erosion control (e.g., Full suspension yarding in LEZ and SEZ, seed and mulch exposed mineral soil areas > 100 ft^2 in RMZ, ELZ, and EEZ, and waterbar cable corridors)	Decrease sediment delivery to streams	1.2.2.2 1.2.2.3 1.2.2.6

Table 1. PL's Proposed mitigation measures to protect/improve aquatic resources.

Activity	Impact of Activity	MSHCP Measure	Expected Benefit(s) of MSHCP Measure	Detailed in Sections
Hillslope Management	Increased sediment	No fire ignition in ELZ and EEZ of Class III streams	Decrease sediment delivery to streams	1.2.2.4
Hillslope Management	Potential for excessive sediment delivery to streams	Default of no harvest and no new roads without a geologist's report recommending alternate prescriptions in areas of "extreme" potential risk	Decrease sediment delivery to streams	1.2.2.6
Hillslope Management	Potential for excessive sediment delivery to streams	No new roads and no heavy equipment off existing roads without a geologist's report recommending alternate urescrintions in areas of "very high" and "high" potential risk	Decrease sediment delivery to streams	1.2.2.6
Rock/Gravel Mining	Habitat modification and sediment inputs	Strict controls on mining methods and levels	Reduce potential for instream impacts	1.2.3
Grazing	Bank erosion and sedimentation	Fencing	Keep cattle out of streams, avoid impacts	1.1.4 1.2.4 1.3.3
Grazing	Bank erosion and sedimentation	Monitoring studies	Identify damage to the riparian area from grazing	1.1.4 1.2.4 1.3.3
Instream restoration/ enhancement	Habitat simplification from past activities	Increase instream habitat, remove passage obstructions; Stabilize unstable streambanks	Increase instream cover, deep water habitats, and spawning sites; Improve fish passage	1.1.5 1.2.5 1.3.4
Fish Rearing and Release	Genetic "contamination" of wild fish by hatchery fish	Wild fish collected for eggs and milt throughout spawning run	Maintain genetic fidelity of fish stocks on ownership	1.1.6 1.2.6 1.3.5
Fish Rearing and Release	Competition with wild fish; Extirpation of fish from areas where historically present	Release fish to areas where populations are low or non-existent	Less overlap of released fish with naturally occurring fish will limit competition; Introduction will help restore the species	1.1.6 1.2.6 1.3.5
Fish Rearing and Release	Competition with wild fish, genetic "contamination"	Release of fry	"Evens" competitive advantage between hatchery and wild fish: Reduces potential for hatchery influence on genetics	1.1.6 1.2.6 1.3.5
Scientific Surveys	Very minor, localized impacts related to surveying and sampling efforts	Continue and expand existing surveying	Provide information on the health and status of fisheries and stream habitat conditions	1.2.7
Land Transfer	No impact anticipated	Headwaters/Elk Springs pact	Increased protection of Elk River drainage; Convert commercial timberland to state/federal park lands	1.2.8
Monitoring and Adaptive Management	No impact anticipated	Modifications of MSHCP as needed to take into account the best available science.	Generally increases protection of all mitigation measures	2.2 2.3
Watershed Analysis	No impact anticipated	Perform watershed analysis	Provide information on the current conditions in each watershed so "customized" management prescriptions can be written	1.2.9

Coarse sediment production from roads is generally associated with landslides. Such landslides are often associated with culvert blockage, deterioration of old wooden crossings (e.g., Humboldt crossings), and fill slope failure in steep terrain (Weaver and Hagans 1994). Although infrequent, such slides can deliver large quantities of sediment to streams, including some fine sediment. Recent studies on PL's lands (PWA 1998A, 1998B) found that roads in some watersheds were an important management related sediment source, but that 80-92 percent of all sediment delivered to streams were from non-road sources.

PL has experienced both erosion of fine sediments from road surfaces, and road-related landslides. Given the unstable geology of much of the ownership, the high rainfall levels, and the fine-grained nature of most soils on the ownership, it is reasonable to assume that road-related sediment will continue to enter streams in the future. Sediments, from both past and future erosion events, can impact fish through the filling of deep water habitats, and by “clogging” the pores or interstitial spaces between individual sediment particles (Bjornn et al. 1977).

The filling of deep water habitats can reduce the survival and total production of trout and salmon. Several studies have shown that the density of trout and salmon has a positive relationship with the abundance of pools (Chapman and Knudsen 1980; Bisson et al. 1982; Tschaplinski and Hartman 1983; Heifetz et al. 1986; Murphy et al. 1986), indicating that deep water habitats can determine the total number of fish that a stream is able to support (i.e., the carrying capacity). Juvenile trout and salmon, especially coho salmon, rely on pools and other deep water habitats for cover and low velocity conditions. In addition, fry and juvenile fish use pools to overwinter and as shelter during fall and winter storms. Without such shelter, both growth and overwinter survival can be expected to decrease. Deep water habitats also provide adult and juvenile fish with protection from predators, and can serve as cool water refugia during warm months when overall stream temperatures are high (Steele and Stacy 1994). Consequently, infilling of deep habitats by road-related sediment could lead to increased rates of thermal stress and mortality. Because deep water habitats are used by all species on the ownership, infilling of these habitats is expected to have negative effects on non-salmonid fishes as well (e.g., Sacramento sucker).

The filling of interstitial spaces with sediment within riffle-pool habitats can also lead to reduced survival and production of trout and salmon. Reproductive success can be reduced because trout and salmon excavate nests or redds in deposits of gravel and small cobble (Chapman 1988). Sedimentation of the gravel that covers eggs within redds can restrict both the flow of oxygen-rich water to and transport of metabolic wastes from developing embryos (Reiser and White 1988). This can result in the death of eggs and embryos. In addition, excessive sedimentation can seal the spaces used by recently hatched fry to emerge from the redd (Chapman 1988). Such “entombed” fry eventually die. Finally, sediment deposition can also reduce the abundance of the prey organisms used as food by fish (Bjornn et al. 1977). Benthic invertebrates inhabit the surfaces of stones and the interstitial spaces surrounding large substrates such as cobble and gravel. As these substrates become embedded by sediments, benthic habitat is eliminated resulting in a decrease in invertebrate production. Lower levels of production of prey organisms can lead to lower growth rates and survival of both salmonids and the other fish species present on the ownership.

1.1.2. Timber Harvest

PL will continue to harvest timber from all portions of its ownership during the term of the Plan. Timber harvest, as used here, includes felling, yarding, site preparation, and replanting of harvested areas. The primary impacts to fish from timber harvest result from delivery of coarse and fine sediments to streams from harvested areas, changes in channel stability and form, and increased water temperatures associated with harvest in riparian areas. As with roads, sediment delivery to streams results from both surface erosion and landslides or mass wasting. Of these two sediment sources, mass wasting is the most significant because of the total volume of sediment that can be delivered to streams (WADNR 1994). In addition, surface erosion is limited to the period between harvest related disturbance and subsequent revegetation of disturbed areas (i.e., 1-2 years or less). Given the fast revegetation of harvested areas and the effectiveness of riparian buffers in filtering sediment (Trimble and Sartz 1957; Lynch et al. 1985), erosion from hillslopes are not believed to be a significant problem on PL's lands. The effects of mass wasting events, by contrast, can last decades and frequently leave large areas of bare soil that are subject to additional surface erosion.

Sediment delivery from harvested areas to streams, like that from roads, increases with increasing slope or proximity to streams. Mass wasting from harvested areas is also strongly related to the inherent geological stability of slopes (WADNR 1994). On PL's ownership for example, some areas appear to be especially prone to post-harvest mass wasting. However, two recent studies on PL's lands (PWA 1998A, 1998B) indicate that many landslides can occur even when no harvest has taken place.

Timber harvest in riparian areas has three main impacts relevant to fish: 1) it reduces the number of large trees that can be recruited into the stream as LWD; 2) it reduces shading of streams, with the result that stream temperatures can increase; and 3) heavy equipment use along streams, in combination with reductions in the abundance/strength of roots that bind soils, can result in bank erosion and channel instability. Past management direction from the state led to removal of LWD from many of PL's streams to "enhance" fish passage, so additional losses of LWD from riparian harvest could be especially important. Similarly, warm summer temperatures associated with many of PL's streams even under old growth conditions means that additional solar heating due to harvest could impact temperature sensitive fish species.

Sediment input to streams from timber harvest activities are expected to affect fish in the same way as sediment input from roads: 1) through infilling of deep water habitats with sediments, and 2) through reduced survival of eggs/embryos of salmon and trout in redds, and reduced invertebrate production in riffle substrates. Specific discussions of these impacts were provided in the analysis of roads, above.

The reduction in LWD from riparian harvest can be expected to reduce pool density, instream cover levels, and gravel retention, primarily through the loss of instream flow obstructions. Based on studies demonstrating the importance of LWD to stream habitat in general, and anadromous fish in particular, (Bustard and Narver 1975a, 1975b; Bisson et al. 1982; Tschaplinski and Hartman 1983; Heifetz et al. 1986; Murphy et al. 1986; McMahon and Hartman 1989; Shirvell 1990), the loss of LWD from riparian harvest is likely one of the most significant impacts of PL's past and future harvest activities to fish. Reductions in the abundance of pools and instream cover may reduce the growth, survival, and total production of all fish species in PL's streams.

As discussed in Volume II, Part H, water temperatures in Yager and Larabee creeks periodically exceed acceptable thresholds for trout and salmon. Cold-water fish, such as salmonids, generally require water temperatures below 20°C (Bell 1973). When these temperatures are exceeded it can result in behavioral changes, decreases in reproductive success, reduced growth, disease problems and mortality (Bell 1973; Moyle 1976; Bjornn and Reiser 1991). Salmonid life history stages influenced by temperature changes include overwintering, migrations (adult and smolts), spawning, egg incubation, fry emergence, and juvenile rearing. Changes in temperature can also have an effect on the availability of dissolved oxygen both in the water column and within the intergravel environment (Ringler and Hall 1975). Reduced dissolved oxygen concentrations can result in direct mortality or suffocation of embryos and emerging fry (Reiser and White 1988). Riparian harvest that exacerbates stream temperature problems is therefore likely to be a determinant of the suitability of different stream reaches for salmonids. Conversely, fish species that prefer warmer temperatures, such as roach and Sacramento squawfish, could benefit from slight temperature increases.

Channel instability from equipment operation within riparian zones and removal of vegetation that provides stabilizing roots can lead to channel widening and a decrease in the depth and sinuosity of some stream reaches. The primary impacts to fish are associated with the filling of deep water habitats, increased solar inputs to streams as they widen, and loss of undercut banks and other instream cover. The importance of each of these habitat elements for fish has been discussed above.

Burning can affect streams by increasing both the nutrient levels (especially nitrogen) and fine sediment delivery to the stream. There is the possibility of riparian vegetation loss if a fire burns into streamside areas. Nutrient levels of streams in redwood/Douglas-fir ecosystems are typically low (Dahlgren in press). In low nutrient systems these slight increases in nutrient levels will actually produce the positive result of increased primary productivity in low and moderate light levels.

1.1.3. Rock and Gravel Mining

An integral element of PL's business operations involves the mining and extraction of hard rock products from upland outcrop quarries and river-run aggregate from near-stream alluvial deposits along the middle reaches of the Eel River. These operations also constitute an essential component of the mitigations and aquatic resource conservation measures provided in the Plan for the control of sediment from roads and other sources. Rocked roads have a much lower potential to deliver fine sediments to the stream channel than unrocked roads. Consequently, without the assurances provided by coverage and inclusion of PL's rock and aggregate mining activities within the Incidental Take Permit, PL cannot practicably commit to implement the road sediment control mitigations described elsewhere in the Plan.

Rock Quarrying

Currently PALCO has two permitted, commercial and numerous non-commercial hard rock quarries. More may be established in the future. Rock Quarry 1/Road 24 is located in the Yager Creek drainage, approximately five miles upstream from Carlotta, California and is situated within the Allen Creek MMCA along the Yager mainline haul road. Pursuant to this Plan and the mitigations provided for management in the MMCAs, existing previously used haul roads and permitted rock quarries within the MMCAs may be used, maintained, stormproofed or abandoned (in the case of permitted rock quarries, closure requires reclamation). This maintenance and use of existing roads and facilities can require the removal of trees, but this necessary activity will be kept to a minimum. The approved Humboldt County conditional use permit, reviewed pursuant to the California Environmental Quality Act, and the approved mining and reclamation plan, reviewed pursuant to the California Surface Mining & Reclamation Act, provide for a total production of approximately 125,000 cubic yards of aggregate material. The entire quarry site includes approximately 3.5 acres.

Rock Quarry 2/Road 9 is located in the Lawrence Creek drainage, Yager Creek watershed, and has been operated for many years for in-house use, prior to the approval of the conditional use permit which allows PL the flexibility to mine hard rock for commercial purposes. The volume of available material in Quarry 2 is estimated at approximately 450,000 cubic yards.

These two existing quarry operations will be covered under the ITPs. If additional quarry sites are proposed, PL may propose amendments to the ITPs and Plan to cover the new operations.

All quarrying operations involve excavation, drilling, blasting, screening, loading and hauling, and activities ancillary to the quarry operation include road relocation, erosion control, annual closure, and final reclamation. Operations at each quarry are seasonal, with most mining occurring from April through November. Minor quarrying may occur from December through March in response to local demand for material or the need to provide material for erosion control or road storm proofing activity. These hardrock mining activities are more specifically described in the February 1997 Mining and Reclamation Plan prepared by Karen Theiss and Associates, filed with the Plan.

PL has been quarrying rock for decades and is aware of few impacts on creeks or riparian areas, most likely because many of them are small or are located in upslope locations. Quarries will be analyzed further during the watershed analysis process. This will provide the company with an opportunity to identify any necessary future mitigations at that time. All existing pits and quarries will be mapped through the watershed analysis process. New pits and quarries will be mapped when constructed.

Near Stream Gravel Mining

PL currently conducts surface mining operations to extract gravel aggregate from river bar deposits in the Eel River upstream from the confluence of the Van Duzen and Eel rivers. PL's existing permit allows for maximum extraction of 160,000 cubic yards per year from several bars; no more than 30,000 cubic yards can be removed from each bar each year, and no extractions are allowed in the wetted channel. Specific annual mining plans and extraction limits are based upon aggregate recruitment and deposition as established by engineered cross-sections and other monitoring procedures, as specified by U.S. Army Corps of Engineers (COE) review.

Potential impacts of gravel mining include: creation of holes in which fish could become stranded, excessive extraction could affect river morphology, and trucks and gravel extraction could prevent establishment of willows and other riparian vegetation. PL believes impacts of its gravel mining on fish and wildlife, as mitigated, are minimal. A National Environmental Policy Act review of the U.S. Army Corps of Engineers letter of permission (LOP) process resulted in a Finding of No Significant Impacts. This, in turn, led to a National Marine Fisheries Service Biological Opinion that concluded any take of coho salmon incidental to permitted gravel extraction would not jeopardize the species. Based on that Biological Opinion, NMFS issued an Incidental Take Statement for the permitted gravel mining activities.

PALCO's LOP (#21641N) was issued last in October 1996 for an effective period of three years or until Dec. 31, 1999. While the permit is effective for a period of years, each year permittees are required to conduct engineered cross-sections of the relevant gravel bens or deposit sites, both before and after extraction operations, if any, each year. Extraction volumes are limited to amounts recruited and deposited each winter, constrained by the maximum permitted volumes described above.

In addition, PALCO's LOP is accompanied by an assortment of mitigation and monitoring requirements as detailed below. We anticipate the same or similar mitigations will accompany any future renewal of the LOP, but in any event PALCO agrees to comply with these measures required as conditions of the permit issued in consultation with NMFS, FWS, and CDFG. In prior years mitigations have included, but are not expected to be exclusively limited to, all of the following:

- PALCO has been expressly required, as an initial matter, to "make every reasonable effort to conduct activities authorized in a manner that will minimize any adverse impact of the work on water quality, fish and wildlife, and the natural environment, including advere impacts to migratory waterfowl breeding areas, spawning areas, and riparian areas."
- All temporary fills within waters of the U.S. shall be removed in their entirety.
- All extraction activities in the vicinity of federal projects shall be coordinated for required setback distances with the COE office prior to application for a permit.

- Heavy equipment working on wetlands shall be placed on mats, or other measures shall be taken to minimize disturbances to soil.

- No authorization will be granted under the LOP procedure for any activity that is likely to jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Endangered Species Act, or that is likely to destroy or adversely modify the critical habitat of such species.

- PL shall notify the District Engineer if any listed species, proposed species or critical habitat might be affected by, or is in the vicinity of, the project, and shall not begin work until notified by the District Engineer that the requirements of the Endangered Species Act have been satisfied and that the activity is authorized.

- The project shall not significantly disrupt the movement of those species of aquatic life indigenous to the water body or those species that normally migrate through the project area.

In addition, the LOP has required significant biological monitoring requirements with data to be obtained by a qualified biologist. These monitoring requirements have included, but are not expected to be exclusively limited to, all the following:

A. Vegetation:

  - All vegetation in each project reach shall be mapped, at a scale of 1 inch = 500 feet for riparian and wetland vegetation and formatted to be consistent to the USFWS National Wetlands Inventory methodology.

  - Mapping consistency shall be provided by the vegetation coordinator on the County of Humboldt Extraction Review Team (CHERT). Riparian and wetland mapping will require the use of current year aerial photo, existing reports and ground truthing.

  - Vegetation shall be typed including age, complexity (using Shannon - Weiner index or other Corps approved index), species composition, and quantified in acreage. Three years after the initial mapping of the project reach, mapping shall be redone.

  - Yearly summaries in vegetational changes in age structure and areal coverage shall be required, and can be supplied using steroscopic aerial photos.

  - Vegetation mapping shall extend a minimum of 100 feet from the top of the banks of the watercourse, or until a change in land use or paved road is found.

B. Anadromous Fish:

- Each project reach shall be mapped for fish habitat, in early summer, using the CDFG's Habitat Level III typing techniques, as provided in the CDFG California Salmonid Stream Habitat Restoration Manual, at a final scale of approximately 1 inch = 500 feet. This mapping effort should use aerial photograph and on the ground visual observations for ground truthing.

- When habitat mapping, the recorder shall make specific note of pool depths, eddies, deltas, key in-channel habitat features formed by large woody debris (e.g. fallen trees, large logs, and root wads), and unique substrate conditions that are of high importance to fish.

- Habitat typing of the project reach shall be redone after three years.

- Temperature readings shall be taken during the same year of mapping, between July 1 and October 31 to help document cold water refugia suitable for anadromous fish, document temperature stratification, and locate cold water refugia.

- Researchers shall record the temperature of the deepest pool at the head of the pool and at its deepest point using continuous recording thermometers (long-term temperature recorders such as hobotemps or stowaways) that only need to be read once per month.

- In addition, temperatures shall be taken at any suspected cold water refugia. Temperature data shall be submitted with post extraction cross sections.

- Project reaches in the lower mainstems of the rivers shall be annually surveyed using snorkeling or visual surveys over a three year period to document adult salmonid upstream migration patterns, use of holding areas such as pools, and how fish generally distribute themselves while they are transporting up the rivers. Surveys shall begin September 1 and continue every ten days through December 1 as water conditions (flow and visibility) permit. Any redds observed shall be mapped. Locations and dates shall be submitted by December 31.

- An annual adult summer steelhead snorkeling survey shall be conducted once each year for three years. The annual survey shall be taken between July 1 and August 31 and will survey all pools within the project reach. Pools where fish are present will be mapped.

- Applicants shall be responsible for developing a joint study, working with USFWS, NMFS, CDFG and the Corps, which will analyze juvenile stranding caused by gravel mining. The study shall include selected sites on the river basins including control sites. A study team of qualified biologists and a statistician shall be selected by the operators and approved by the Corps to develop and run the study. Results shall be documented and analyzed yearly. One research group shall study all sites to obtain consistency of results.

C. Amphibians

- After completion of the Level III fish habitat mapping, each project reachwill be surveyed once in early June, August and October to determine the presence or absence of foothill yellow-legged frogs, northern red-legged frogs, and bullfrogs. Surveys will focus on the ponded areas within the floodplain as well as shallow, slow moving water along the river's edges.

- During the tri-yearly surveys, all suitable habitat shall be investigated and delineated on appropriate aerial photos. Data recorded will include water temperatures taken during the survey, and number of sightings of adult, juveniles, egg masses and tadpoles seen.

- Visual inspections shall include scans of the stream banks and rivers' edges for egg masses, tadpoles, and adults. If adults are present, the surveyor shall note any adverse affects of the operations on amphibians.

D. Birds

- Any gravel operation that begins in the spring (March, April or May) may adversely affect nesting and brooding activities of avian species.

- Monitoring of avian species to determine use of riparian areas and gravel bars according to sex, age, and breeding status may be required of any operator that commences gravel extraction before June 1.

- Monitoring shall include point counts and mist netting and shall be approved by CDFG and USFWS personnel.

E. Mammals and Pond Turtles

- No surveys shall be required for mammals and pond turtles, however, anecdotal information shall be recorded during other surveys and shall be submitted to the Corps.

1.1.4. Grazing

PL has approximately 5,800 acres of grazing land under lease to private cattle operations (see Map 32 in Volume V). Currently about 600 head of cattle graze this area. This number is decreased from a historical use of 2,000–3,000 head of livestock. Throughout this section the term head refers to cow/calf pairs.

There are fifteen different areas that are leased for grazing. Most of these areas contain exclusion measures or have inherent site features that limit livestock access to streams. The grazing areas and factors limiting stream impacts for each area are shown in Table 2.

Under this Plan, the number of head will not exceed 1,000 at any one time during the term of the ITPs.

Grazing activities can impact stream areas through bank erosion, sediment inputs to streams, and excessive grazing of woody vegetation. In addition, it is possible that cattle could directly impact aquatic species through trampling, although studies documenting the magnitude or likelihood of such effects could not be located by PL. Typically, impacts of cattle in riparian areas are proportional to the density of cattle, the frequency with which they are moved to different grazing areas, and the degree to which they are excluded from riparian areas by fences or other measures. Since cattle are often attracted to riparian zones they can use these areas with greater frequency than non-riparian lands within their range.

Soils tend to become more compacted in areas where cattle concentrate. Compaction of soil outside riparian areas reduces infiltration of water into deep soils increasing surface runoff, which, in turn, can increase fine sediment transport into streams. Compaction of soils in the riparian zone can also lead to increased sediment inputs, and may result in changes in vegetation from perennial species with deep, fibrous roots to annual species with shallow, fine roots.

Cattle use of areas adjacent to stream channels can result in bank damage. Damaged banks can introduce large amounts of sediments into streams. These sediments can result in stream widening and/or the filling of interstitial spaces between cobbles and gravels. Fine sediments can also reduce subsurface waterflow, resulting in lower rates of prey production and fish embryo survival and emergence. Filling of interstitial spaces also reduces fry habitat, requiring them to use more open areas where they become vulnerable to predators. In the water column, fine sediments cause turbidity, which, in extreme cases, can reduce primary productivity and alter food webs within the stream zone.

Where streambanks are stable, they often provide cover and velocity breaks (e.g., overhanging vegetation) that are important habitat attributes for aquatic species. Cattle use of riparian zones can result in loss of these habitat features. Under worst case conditions, grazing can result in removal of nearly all riparian vegetation, and cause stream banks to “lay back” such that they have neither overhanging vegetation or undercut banks. Such sites have both lower habitat value and an increased risk of stream warming (from decreased shading) that could adversely affect aquatic species.

Table 2. Grazing Areas on Pacific Lumber land.

Parcel Name	# Acres	# Head	Factors Limiting Impacts to Aquatic Resources
Yager Camp Area	12	<10	Used for growing hay primarily. Fenced to prevent cattle from getting into Yager Creek when any are present.
Corbett Ranch Area	23	<10	Primarily used for growing hay, has few cattle if any.
Riverside Acres	30		Primarily used for horse grazing and growing hay.
North Rainbow Ranch	830	100	High prairie piece. Several factors limit cattle access to streams in or near this parcel: the area contains many steep slopes that keep livestock close to the ridge tops and away from watered areas, water sources are provided for the cattle (springs), and many fences have been built to keep the livestock on the ownership. Roads that are used for access in these areas have fences and locked gates.
South Rainbow Ranch	1797	100	The parcel and factors limiting cattle access to streams are very similar to those for the North Rainbow Ranch. However, cattle within this parcel, unlike North Rainbow Ridge, can access streams in several places. This area has many roads that run through open land mixed with timber. Cattle use the roads to travel between prairie openings, usually crossing watercourses via bridges or culverted crossings. Due to the steepness of this area, the cattle tend to use side hill trails when they are not able to use a road. Therefore, most crossings of creeks off roads occur at established locations.
Chalk Mountain Area	71	10	High prairie surrounded by timberland, cattle tend to stay on the prairie. Water is provided by a spring.
Patmore Cabin Area	442	30	High prairie surrounded by timberlands.
Moore's Prairie	160	30-40	Water is provided by springs. Cattle stay near their feeding areas. The parcel is located away from any river or fish bearing stream. Impacts are also limited by the low stocking rate.
Chase Ranch	1250	130	Some of this acreage is fenced to keep the herds separated and to keep the cattle from the Class I watercourses. In areas not fenced to prevent cattle entry to WLPZs, the steepness of the ground tends to limit movement into creeks.
Hartman Ranch	450	40	Fenced in high prairie piece. Water is provided by a spring.
Bowlby Piece	40	20	Fenced in high prairie piece. Water is provided by a well. No cattle get into any streams or rivers on this land.
Townsend Ranch	100	20	Midslope piece surrounded by forest. The cattle tend to stay in the open areas. Water is provided by a spring.
Moore Ranch	200	30	Fenced in piece. Water is provided by a spring that is fenced to keep the cattle out.
Schmidbauer Ranch	350	none yet	Fenced in high prairie piece. Water is provided by a spring.
Casacca Ranch	24	30 yearlings	Fenced in piece that is also fenced at the creek. Cattle do not have access to the watercourse from PL's property.

Additional impacts to the stream could occur from direct introduction of cow manure and urine. Survival of fecal coliform and streptococci bacteria have been found to lengthen in benthic sediments of streams (Sherer et al 1992). PL could fine no literature discussing negative impacts of these bacteria on fish or fish eggs. Nutrient levels in redwood/Douglas-fir ecosystem are typically low (Dahlgren in press). In low nutrient systems slight increases in nutrient levels will actually produce the positive result of increased primary productivity in low and moderate light levels.

Although the potential impacts of cattle grazing are high, in practice most streams on PL's ownership show little or no impacts of grazing. This is because grazed lands are relatively rare on the ownership, and are located in discrete patches, often on ridgetops away from streams. In addition, cattle stocking levels are kept low, and, as noted above for individual parcels, many sites contain fences or features that limit cattle access to riparian areas.

1.1.5. Instream Habitat Improvement

Since 1980 the PL and the CDF&G have worked cooperatively with the California Conservation Corps (CCC) to implement stream improvement projects on streams within PL's ownership. The program's general goal is the protection, restoration, and enhancement of anadromous fishery resources in watersheds owned by PL. Efforts to accomplish these goals include: stream habitat inventories, biological inventories, project planning, instream structure placement, and monitoring and evaluation.

Habitat and biological inventories provide the baseline data used to identify streams or stream reaches that are suitable for restoration or improvement activities. Project planning involves an additional survey to write a site specific work plan for the construction crews to follow. Instream structure placement, monitoring and evaluation involves constructing habitat structures and determining their effectiveness over time. Each of these efforts is described in detail below.

Habitat Inventories

Habitat inventory as described in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998) consists of channel typing developed by Rosgen (1994) and habitat typing originally developed by Bisson et al. (1982). The inventory results provide the baseline data necessary to determine if stream conditions may be appropriate for habitat enhancement projects. If habitat projects are recommended and implemented, baseline data are also essential for project evaluation and monitoring. Historically, crews from the CDF&G have performed all baseline habitat inventory surveys. Although not part of past survey work, PL is currently developing a research program to determine the effectiveness of instream habitat improvement structures that have been installed.

Habitat inventories are conducted using methodologies from the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998) unless otherwise indicated. This manual includes a standardized habitat inventory form that is used to record measurements and observations. The nine components to the inventory form include:

1) Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated.

2) Channel typing is conducted according to the classification system developed and revised by Rosgen (1985, 1994). The five measured parameters used to determine channel type are: water slope gradient, entrenchment, width/depth ratio, substrate composition, and sinuosity. Channel typing is conducted simultaneously with habitat typing.

3) Habitat typing uses the 24 habitat classification types defined by McCain (1988). Habitat units are numbered sequentially and assigned a type identification number. Dewatered units are labeled ”dry”. Habitat typing uses standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the streams' mean wetted width. Channel dimensions are measured using hip chains, range finders, tape measures, and stadia rods. Mean length is measured for all units. The first occurrence of each unit type and a randomly selected 10 percent subset of remaining units are sampled for all features (Hopelain 1995). All pool units are measured for maximum depth, depth of pool tail crest, and embeddedness. Pool tail crest depth at each pool unit is measured in the thalweg. All measurements are in feet to the nearest tenth.

4) Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit. Water temperature is taken within one foot of the water surface.

5) Embeddedness in pool tail-outs (i.e., the downstream edge of pools) is measured using ocular estimates of the cobbles surrounded or buried by fine sediment. The values are recorded using the following ranges: 0-25% (value 1), 26-50% (value 2), 51-75% (value 3) and 76-100% (value 4). A value of five is assigned to tail-outs deemed unsuited for spawning due to bedrock, inappropriate substrate particle size, or other considerations.

6) Instream shelter is composed of those elements within a stream channel which provide salmonids with protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. The shelter rating is calculated for each fully described habitat unit by multiplying shelter value and percent cover. From an aerial (i.e., overhead) perspective, percentage of the habitat unit having cover is estimated (0-100%). A standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) is then assigned according to the complexity of the cover. Shelter ratings can therefore range from 0-300 and are expressed as mean values. All cover is also classified according to a list of nine cover types.

7) Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully described habitat units, dominant and sub-dominant substrate types are ocularly estimated using a list of seven size classes and recorded.

8) Stream canopy density is estimated using modified handheld spherical densiometers. Canopy density relates to the amount of a stream shaded from the sun. An estimate of the percentage of the habitat unit covered by canopy is made from the center of approximately every third unit in addition to every fully described unit, giving an approximate 30 percent sub-sample. In addition, percentages of coniferous and deciduous trees that compose the canopy are estimated.

9) Bank composition elements range from bedrock to bare soil. Vegetation along stream banks usually consists of grass, brush, or trees. These factors characterize the ability of stream banks to withstand winter flows. The dominant composition type and the dominant vegetation type of both the right and left banks for each fully described unit are identified. Additionally, the percent of each bank covered by vegetation is estimated and recorded.

Biological Inventories

To date, all biological inventories on PL's ownership have been conducted by CDF&G. However, as with habitat inventories, PL is currently developing a program to collect its own data on fish and amphibian abundance. Fish distribution studies are expected to be part of both watershed analysis and monitoring studies that PL will conduct (see Sections 1.2.9 and 2.2). This will provide baseline information that provides a general assessment of fish presence, distribution and habitat utilization within a stream. Project personnel during the past inventories have used stream bank observation, direct observation and/or electrofishing as methods to sample and describe fish resources. Stream bank observation is used to determine the presence or absence of fish. Direct observation can be used for presence or absence as well as quantification of species. The primary drawback to these methods of observation is that species level identification is difficult. Therefore, electrofishing methods are used when more quantitative surveys of fish species are needed. Biological sampling during stream inventories is used to determine fish species and distribution in the streams.

For past CDF&G surveys fish-sampling density is determined according to the number of Rosgen channel types in each stream. In general, each Rosgen channel type in each stream is electrofished in a single pass. No block seines are used. All fish captured are anesthetized, identified by species, recorded, and returned to the stream. PL expects to use a three-pass electrofishing method with block nets for quantitative surveys, and direct observation and snorkeling for most qualitative surveys.

Project Planning

For the streams that have been surveyed by crews from CDF&G, a stream inventory report is written summarizing the habitat and biological inventory. It also provides a list of recommendations for instream enhancement projects. Personnel from both PL and CDF&G prioritize and rank the stream projects by biological soundness, location of potential work reaches, greatest need for enhancement, and potential for cost share. For every project that is then selected for instream restoration, a site specific work plan must be written. Starting at a known point, usually the stream confluence, the stream is surveyed for work locations. At each identified work site the following information is recorded: site location in feet from the starting point, present condition of the site, objective of the project, project description, estimated labor to complete the project, materials and supplies needed, and a diagram of the site. Projects are categorized into either instream habitat improvement, fish passage improvement or watershed and stream bank stability improvement. Descriptions of each of these categories are included in Flosi et al. (1998). Prior to any project being implemented, all required environmental review, and permits are secured. These include but are not limited to:

- California Environmental Quality Act (CEQA);
- CDF&G Stream Alteration Agreements, Sections 1600-1607;
- U.S. Army Corps of Engineers 404 Permit;
- California Regional Water Quality Control Board 401 Permit.

Project Construction, Monitoring and Evaluation

Habitat projects are designed and implemented with specific goals for restoring, improving, enhancing and/or maintaining stream habitat conditions. On-site project work is completed using heavy equipment and hand crews. Access to the site is created and a supply of any necessary building materials (e.g., logs, boulders) is moved to the work location. Different approaches are used to establish instream projects and may include:

- Boulder bank protection or riprap is used for the stabilization of the toe of eroding banks. A toe trench is constructed in the channel alongside the erosive bank. Large boulders are then placed in the toe trench. After the first course is completed, successive layers are positioned until the prescribed height is achieved. Smaller bank protection projects may use logs exclusively. The logs are secured to the bank with cribbing logs. Each successive layer of logs is alternated with bank protection logs, followed by cribbing logs until the prescribed height is attained.
- Log pool development is completed by excavating a trench across the normal wetted stream channel and into both banks for keying in the log. A log is then placed in the trench and backfilled. Boulders are also used for weir construction material. Procedure for construction is the same except for materials. Another pool development weir may be constructed with a combination of both logs and boulders. Typical designs for weir construction include single boulder or log weir, combination boulder/log constricting weirs, and single or opposing log / boulder deflector.
- Cover structures are constructed by placing a boulder or cluster of boulders at the prescribed location. Alternatively, log cover structures may be anchored in the channel to existing or placed logs or boulders or extended from the bank in various designs.

- Fish passage by boulder step-pool weirs facilitates access into higher reaches in the stream across barriers. This construction consists of a stair-step design of small vertical raises alternating with deep pools. This arrangement provides resting areas for the fish as they progress up the structure.

Monitoring and Evaluation

Monitoring habitat enhancement projects begins with quality control. CDF&G's administrator inspects all work at each major stage of project completion. Inspections are done at several stages before, during, and at the completion of the project. The CDF&G administrator generates an inspection report at each visit. A finalized report is only given after the entire project is completed.

Through the process of evaluating habitat projects, it can be determined if intended goals have been achieved. The methodologies followed for project evaluation are described in the Flosi et al. (1998). Starting at a known point, usually the stream confluence, the stream is surveyed and at each project site a "Structure or Site Evaluation Form" is completed. Typical information collected for this form includes the type, number and condition of structures, project completion date, as well as how the structure is meeting the habitat objective.

To date surveys of fish utilization of insteam structures have been done sporadically or not at all. PL intends to begin performing such surveys, and to compare fish abundance by species with abundances in similar areas without artificial structures. This work is expected to begin this summer and to continue for several years.

PL also intends to continue its cooperative instream habitat enhancement program with CDF&G. In addition, PL may expand its restoration activities. Individual stream enhancement projects will be designed to enhance fisheries habitat or channel conditions. Future projects will likely include the stabilization of stream banks, increasing pool frequency in the stream channel, retention of spawning gravel, and adding LWD to increase the quality of summer rearing habitats. Other projects will be designed to remove fish migration barriers. All of these operations are expected to result in improved habitat for salmon, steelhead and other aquatic organisms and therefore, should result in increases in abundance of these taxa. To avoid impacts to spawning, and to reduce sedimentation problems, the majority of activities will occur from May 1st to October 31st.

Even though instream habitat improvements have a very positive effect on aquatic conditions, there is the potential for some minor negative impacts. These negative effects are negligible and short term. These include direct, indirect, or cumulative impacts on salmonid resources and may include:

- Direct kill during the inventory stage or during construction
- Noise disruptions associated with the operation of heavy equipment
- Risk of accident or upset with heavy equipment

- Disturbance due to heavy equipment when accessing the stream channel
- Short term increases in turbidity during and after installation of instream structures

Direct kill can come about during collection of data for stream inventories or during the construction of instream habitat structures. During the stream inventory survey period, disruption of redds, or driving juvenile salmonids from their summer rearing habitat may occur. In the summer months, crews performing physical and biological surveys may displace fish from normal rearing and feeding stations. In some cases a field survey is conducted prior to the construction of instream structures to determine the location and presence of salmonids. Most of the salmonids encountered during the survey are then moved away from the construction site. Mechanical manipulation of existing habitat may displace or harm juvenile salmonids. Compaction to late incubating redds and juvenile salmonids is one possible direct negative effect. Limiting the use of heavy equipment to the summer months minimizes impacts to redds. Older and larger sized juvenile salmonids have a better chance of escaping at this time as well. Biological surveys may also accidentally kill fish during some stage of electroshocking or handling.

Noise from equipment is present during most construction. The noise originates from the equipment working at the site. Although the impacts on aquatic species are minor, the noise may impact some wildlife species. The increase in noise is short in duration and is not expected to have adverse effects on fish or wildlife in the area.

Risk of accident or upset of heavy equipment fuels and oils is minimal. All heavy equipment used in projects is cleaned and inspected for leakage of petroleum products before work is started. The machines are in good repair and free of oil leaks before they are used on the project. Petroleum product absorbent materials designed specifically for oil spill containment and clean up is stored on heavy equipment during project construction for use in case of an accident.

There is typically only a minimal amount of disturbance due to heavy equipment accessing the site. Most projects can be constructed from outside the wetted stream channel. However, there are cases in which equipment must work in the active channel. Access is made at existing stream crossings. If needed, new access points are made in locations that provide passage to more than one project site. Potential negative effects associated with heavy equipment access include minor disturbance to grasses, shrubs and other riparian vegetation. Special care is taken not to disturb any mature tree or snag. Riparian vegetation is re-established where construction activities disturb existing plants, and additional native plants are added to enhance the riparian vegetation within the project reach. Disturbed or bare soils resulting from project activities that may be subject to surface erosion are seeded and straw mulched.

Turbidity normally increases during excavation of the toe trenches, keyways and installation of instream structure components (logs and boulders). Minor surface erosion occurs at work sites during the first storm after project completion where the soil has been disturbed by heavy equipment. To minimize the negative aspects of turbidity during construction of instream structures silt catchment fences are installed across the stream channel immediately downstream of work sites. This captures suspended sediment and allows settling during the construction phase. The silt fences are then removed from the stream following completion of the project. Where feasible, stream flow is diverted towards the opposite bank prior to excavation to prevent an increase in turbidity downstream. Disturbed or bare soils resulting from project activities subject to surface erosion are also grass seeded and straw mulched. Erosion of soils caused by project implementation is minimal. After completion of the project, some streambed scour and deposition will occur during the first winter rainstorm. This will likely cause some short term and minor increase in turbidity as the streambed accommodates to the modified stream channel.

Given the overwhelmingly positive impacts of instream habitat restoration work, the potential negative impacts are minor and acceptable. PL's and CDF&G's ongoing stream monitoring programs will provide ongoing data on the effectiveness and impacts of instream work. If these studies indicate some problems exist, then restoration approaches will be modified accordingly.

1.1.6. Fish Rearing Facilities

PL, in cooperation with the CDF&G, operates a variety of fish rearing facilities. The fish rearing facilities are part of a larger partnership with CDF&G to assist in the recovery of salmonid stocks on the North Coast. The emphasis of the fish rearing program is to restore self-sustaining populations of wild fish on PL's ownership, rather than to increase the number of fish that can be commercially or recreationally harvested. This is accomplished by obtaining eggs and milt (sperm) from wild fish, using them to produce salmon and steelhead in small ponds and acclimation tanks, and planting the fish in streams on PL's ownership. The fish rearing program is supervised by CDF&G administrators, who review the annual performance and operation of the hatchery, determine the number, sex and species of broodstock to be trapped, and set limits on the number of eggs that can be collected. The species, number, location and timing of fish releases into streams are also reviewed prior to approval of PL's annual permit.

Covered Activities at PALCO's fish rearing facilities include the incidental taking of non-targeted, listed species such as the coho salmon, which may be unintentionally trapped, captured or taken in the course of collection of unlisted species during the otherwise lawful activities. Targeting listed species for collection will require an ESA section 10(a)1(A) permit. That is, to the extent that coho salmon, or any other listed fish species are purposely collected for the fish rearing facilities, a scientific collecting permit will be required from NMFS. Thus PL's HCP seeks authorization only for incidental take of listed species associated with the collection and rearing of non-listed species.

Although the primary emphasis of the fish rearing program is on restoration of self sustaining wild populations, the program also has an educational role.

- The company's main hatchery facilities are located at Yager Camp, the headquarters for PL's timber operations. PL woods personnel and personnel hired to work within the Yager Creek Basin pass by the hatchery and have open access to the hatchery. Furthermore, PL woods workers assist in trapping, spawning, rearing, feeding and releasing fish in the watershed during the winter months. This develops a positive awareness in the personnel on the watershed when they return to work on timber production the following spring.

- The fisheries program, with assistance from CDF&G program administrator(s), has included seminars for the company's heavy equipment operators. The goal of these seminars is to increase "on the ground" awareness of how to avoid impacts to streams and riparian habitat.

- PL participates in the "Classroom Incubation Program" for young students. The program introduces students to the life history and habitat requirements of anadromous fish, and provides selected school groups with small numbers of eggs which they can incubate in their classrooms. The program has been developed as a model for other large parcel landowners and timber based companies on the north coast of California.

- PL has recently developed a "state of the art" educational fish rearing facility in Scotia, California. The "Anadromous Fish Demonstration Facility" is designed to give both local citizens and tourists traveling through the area an opportunity to see a variety of exhibits that explain anadromous fish life histories, the effects of forestry on stream habitats and fish, and measures being taken by PL to protect aquatic resources.

Currently, eggs and milt are collected only from adult fish migrating in streams within the Yager Creek Watershed, and all fish releases are conducted in streams within this basin. However, PL anticipates that its fish rearing program could be expanded in the future to include collections/releases from other basins within its ownership.

PL currently collects approximately 100,000 chinook salmon eggs from 35 female adults and milt from 35male adults each year. Annual releases of juvenile chinook salmon have ranged from 2,636 to 85,500 (Table 3). Collected eggs are incubated until hatching, after which juvenile fish are moved to and reared in separate facilities. CDF&G has established guidelines on size at release and the timing of releases of juvenile fish. PL is currently following these guidelines, which calls for chinook salmon to be held in rearing facilities until they reach at least 90 fish/lb. This occurs around mid to late May. The guidelines also provide for rearing chinook salmon to a "yearling" size of 12 fish /lb which generally occurs by late October.

PL also collects approximately 30,000 steelhead eggs from 10 female and milt from10 male steelhead trout yearly. Annual releases of steelhead juveniles have ranged from 6,500 to 52,000 (Table 3). Steelhead trout are reared for one year prior to their release between 15 March and 1 May. Steelhead average 10 fish/lb at release. Steelhead are typically released into stream sites that have undergone restoration work (e.g., construction of rock and log structures) to increase rearing habitat, or in stream reaches where steelhead are absent or present only in very low numbers.

Table 3. Hatchery releases of chinook, coho, and steelhead into respective WAAs.

Year	Hatchery Source[1]	WAA [2]	Chinook	Coho	Steelhead
1964	HFAC	Humboldt		20,000	
1965	HFAC	Humboldt		52,000	
1966	HFAC	Humboldt	4,650	28,801	
1967	HFAC	Humboldt	16,102	43,061	
1968	HFAC	Humboldt	16,668		
1973	PL	Eel			6,970
1974	PL	Eel			61,410
1975	PL				24,000
1976	PL	Eel			4,385
1977	PL	Eel			8,230
1978	PL				1,869
1978	PL	Eel			3,472
1978	PL	Mad River			7,020
1979	PL				20,520
1980	PL				9,690
1980	PL	Eel			7,860
1981	PL	Eel			11,050
1981	PL	Yager			30,000
1982	PL				6,560
1982	PL	Eel			28, 896
1982	PL	Yager	2,636		
1983	PL	Eel		10,665	
1984	PL	Eel			10,360
1985	PL	Eel			21,296

Table 3. Hatchery releases of chinook, coho, and steelhead into respective WAAs (Cont.)

Year	Hatchery Source[1]	WAA [2]	Chinook	Coho	Steelhead
1985	PL	Yager	6,688		4,840
1986	PL	Eel			11,808
1986	PL	Yager	7,310		3,427
1987	PL	Eel			11,970
1988	PL	Eel			13,500
1988	PL	Yager	51,750		
1989	PL	Eel			8,900
1989	PL	Yager	19,992		
1990	PL				7,090
1990	PL	Eel			13,652
1991	HFAC	Humboldt		17,100	
1991	PL	Eel			9,460
1991	PL	Yager			3,570
1992	HFAC	Humboldt		7,000	10,900
1992	PL	Eel			11,200
1993	PL	Humboldt	14,850	6,500	
1993	PL	Yager	85,500		4,600
1994	HFAC	Humboldt	34,585		
1994	PL	Yager	38,500		20,360
1995	PL	Yager	45,000		6,500
1996	PL	Yager	48,290		6,100
1997	PL	Yager	24,800		9,780

[1] PL = releases from Pacific Lumber hatchery facility on Coopermill Creek
HFAC = released from the Humboldt Fish Action Council's hatchery in the Freshwater Creek drainage.

[2] Blanks indicate that the specific site of the release is not known.

NR No hatchery releases from the organization during that year.

PL has state permits to collect up to 30,000 coho salmon eggs/year from 10 female fish and milt 10 male fish. However, given concerns about the status of coho salmon in the Northern California Coast/Oregon Coast ESU, PL has chosen not to collect and rear coho salmon for several years. However, PL intends to begin rearing coho fry and releasing them into stream areas having suitable habitat but little or no wild fish production. Before this effort is undertaken PL will obtain a federal 10 (a) 1(A) permit before using coho salmon in its fish rearing program.

Equipment and methods used at PL's fish rearing facilities are as follows:

- Egg incubation is completed at PL's hatchery along Yager Creek. The incubation room has three 16 tray "Heath stack" vertical incubators. A 20,000-gallon water tank that is fed from groundwater sources and a licensed diversion from Cooper Mill Creek supply the water for incubation as the primary and secondary sources of water. This water is gravity fed to a slow sand filter, then to an overhead water trough to accommodate three 16-tray vertical incubators. Water flow is adjustable up to 9 gallons per minute per stack depending on the number of eggs being incubated, stage of incubation, etc.

- Eight fiberglass fry rearing troughs (8 ft long by 2 ft wide) are located at the hatchery. These troughs serve to provide for primary feeding and growth of recently hatched fish (i.e., fry). All troughs have a water capacity of 105 gallons. Water supply is from the same diversion in Cooper Mill Creek. Backup water is supplied from the above described 20,000 gallon water tank. Water delivery per trough can range from 10 to 15 gallons per minute.

- Most juvenile (i.e., fingerling to smolt) rearing is completed at PL's hatchery along Yager Creek. Two California raceways are connected in a series, 100 ft long X 20 ft wide at the top, 10 ft wide at the bottom X 4 ft deep. A holding area is located between the two ponds. This holding area is 12 ft long X 5 ft wide X 6 ft deep. The gradient of the raceways is 6 in. in 100 ft. The raceways and holding areas are concrete lined. Water supply from the diversion in Cooper Mill Creek is conveyed to the head of the raceways with a combination of 300 ft of 8 in. steel pipe and 400 ft of 10 in. steel pipe. Recirculation of water in the raceway is accomplished by using the pump at the tail end of the raceway and directing the water to the spray bar at the head of the raceway. This pump has a capacity of 90 gallons per minute.

- Fingerling to smolt rearing is also conducted in a separate 2,500 gallon circular tank at PL's hatchery. This tank is supplied by a 3-in. PVC line originating from the diversion in Cooper Mill Creek. Water delivery ranges to 60 gpm. The backup water system is from the existing 20,000 gallon water supply tank.

- To date, the Anadromous Fish Demonstration Facility has not been used for rearing. However, PL anticipates that it will be used for rearing, at least on a small scale, beginning this summer. The facility contains a concrete lined rearing tank approximately 150 ft long by 12 ft wide. Water level can be adjusted from 0 to 5.5 ft deep. A separate 1500 gallon half circular rearing tank is also present at this facility. Water source is from a domestic water tank that supplies the town of Scotia, California. Water enters the facility and is directed to a sump. From here it is pumped through a sand filter, chillers and UV light unit prior to being directed into the fish display or the separate rearing tank. Water capacity of the display is approximately 45,000 gallons. Flow rate is adjustable and is maintained at 300 gallons per minute. Water is recirculated in this system with approximately 15 percent make up to recover from daily evaporation.

Although PL's fish rearing facilities are meant to have a positive impact on fish populations within the ownership, some negative impacts are also possible. Many of these negative impacts are associated with genetic changes associated with fish rearing within hatcheries. Genetic changes can result from three primary sources. First, adult fish collected for eggs/milt may come disproportionately from a particular time period within the adult migration period. Most often, brood fish are collected from the early part of the run so that hatchery managers inadvertently select fish with genes coding for early migration. Second, fish reared in hatcheries are subjected to different selective pressures than fish in streams. Thus, for example, genetically inferior fish that might normally die in natural environments may survive under the benevolent conditions in hatcheries. Third, many hatcheries select adults of hatchery origin for their eggs/milt. To the extent such hatchery origin fish have altered genetics, such selection tends to intensify genetic "drift" away from the genome of wild fish. Wild fish, in general, experience a harsher environment, and therefore stronger selective pressures, than hatchery fish. This stronger genetic selection may explain why smolt-adult survival rates for wild fish are frequently much higher than for hatchery fish.

Hatchery fish can also have a negative effect on wild fish populations by competing for food or habitat upon their release into streams. Hatchery fish tend to move out of streams in higher numbers, to be more active (less reclusive), to use less cover habitat, and to be more aggressive than natural fish. This has been shown to displace and cause behavioral shifts in wild fish (Peery and Bjornn 1993). Although the release of smolts from hatcheries is meant to reduce the potential for competitive impact (i.e., because smolts rapidly migrate downstream to the ocean) the sheer number of fish released can still result in significant reductions in the food and space available to wild fish. Other possible impacts of hatchery fish include: transmission of diseases or parasites to wild fish, overharvesting of wild fish that are intermixed with hatchery fish (i.e., mixed stock fisheries), and large concentrations of planted hatchery fish may attract larger than normal numbers of birds, fish and other natural predators.

1.2. AQUATIC HABITAT CONSERVATION MEASURES TO BE IMPLEMENTED UNDER THE PLAN

PL has developed a number of HCP measures directed at both riparian and upland areas (Table 1). Many of these measures have already been implemented by PL, and in some cases have been a component of PL's land management for years. Other measures represent new management commitments developed specifically for the Plan. New measures were developed in four ways: 1) in response to PL's internal analysis of fisheries and water quality conditions on the ownership, 2) using input obtained from CDF&G, NMFS, and other regulatory agencies, 3) based on a review of stream and fisheries measures incorporated into other multi-species HCPs that have been prepared for forest lands in the Pacific Northwest, and 4) by identifying management measures and mitigations that will lead to streams on the ownership trending toward habitat condition “goals.” A discussion of the specific measures being proposed to mitigate each of the management activities that was discussed in Section 1.1 is presented in this section.

The specific HCP measures PL will implement is determined via a three "tier" system: interim prescriptions, prescriptions resulting from watershed analysis, and default prescriptions. Interim prescriptions are those measures presented in detail here. They were developed jointly with the agencies over a period of months based on an extensive review of the scientific literature and on an analysis of the cost and operational feasibility of specific mitigation measures. Collectively they are expected to provide a high level of protection for aquatic resources on PL's lands. The interim prescriptions are already being phased into PL's operations and can remain in force for a period of up to three years following the issuance of the incidental take permit.

PL has committed to conducting watershed analysis on its lands. The interim prescriptions described above may be modified for portions of PL’s ownership after completion of these watershed analysis studies. Watershed analysis is designed to use additional data and studies to develop site specific mitigation measures. Such site specific mitigations are customized for the different conditions on PL’s ownership, and are therefore superior to the “one size fits all” approach to mitigation embodied within the interim prescriptions. All such watershed analysis will be conducted in collaboration with regulatory agencies, who must approve the resulting site specific prescriptions that emerge from the analysis process. See this Section 1.2.9 for more details on watershed analysis.

As noted, the interim prescriptions described here can apply for a period of three years following issuance of the incidental take permit. After this time, any portions of PL's lands that have not been assessed through watershed analysis and/or do not have site-specific prescriptions approved bu the agencies will be subject to the default prescriptions contained in Section 3 of this HCP document except that, as stated in the Pre-permit Agreement in Principle, issues related to this default strategy need to be resolved prior to its implementation. PL and the agencies have not yet fully resolved these issues to finalize this default strategy. The agencies view the default prescriptions as being more protective of aquatic resources than the interim prescriptions. PL shares this view but considers that the default prescriptions, as written, will impose significantly greater economic and operational constraints on the company than either the interim or site-specific prescriptions. Accordingly, PL expects that the negotiation process for the default prescriptions will address how to reduce their operational and economic impacts while still maintaining a higher level of resource protection.

1.2.1. HCP Measures for Road Construction and Maintenance

PL has proposed several Plan measures that specifically address road related impacts: 1) continuation of a program to storm-proof existing roads at a rate of at least 500 miles/decade, 2) all new roads will be built to storm-proof specifications, 3) all storm-proof roads will be maintained to the storm-proof standard, 4) THP related roads will be upgraded as needed to provide for adequate road drainage and erosion control, 5) all THP related roads will be inspected at least annually for three years after operations, 6) all open roads will be inspected at least yearly, 7) any maintenance needs identified by inspections will be performed by the end of the field season following the inspection, and 8) road use and construction will be limited during periods of precipitation. PL has also agreed to conduct analyses of sediment contributions from roads as part of the sediment budget studies that will be performed during the storm-proofing and watershed analysis processes. Collectively these HCP measures will have a variety of positive effects on road-related impacts to aquatic resources on the ownership.

1.2.1.1. Assessment of Road and Associated Sediment Sources

PALCO will assess the road network and associated sediment sources on its lands either as part of the watershed assessment or the road storm-proofing program protocols (see below). Given the accelerated schedule being proposed for watershed analysis, most of this assessment is likely to occur within the first few years after issuance of the ITPs. However, at a minimum, the assessments must be completed as follows:

- Elk River, Freshwater Creek, Lawrence Creek, and Yager Creek will be evaluated within the first decade of Plan implementation;
- Van Duzen and Middle Eel rivers will be evaluated during the second decade; and
- Larabee Creek, Salmon Creek, and Mattole and Bear rivers will be evaluated during the third decade.

It is anticipated that all sites assigned a high or medium priority rating based on the audit of potential sediment sources will be storm-proofed over the first 30 years of Plan implementation.

1.2.1.2. Road Storm-proofing

In each decade of HCP implementation, or until all active roads have been storm-proofed, at least 500 miles of existing roads will be improved to meet the storm-proofing standards identified in the PWA guidelines (Volume II Part N). PL will work closely with agencies to identify priority areas for this work. Additionally, unless otherwise agreed to by the agencies pursuant to prioritization discussions, storm-proofing will proceed according to the schedule by decade for hydrologic units provided in the January 7, 1998 Interagency Aquatic Strategy on page 10 thereof (see Section 3). Storm-proofing conducted as part of THPs will count towards the per-decade objective. When used in this Plan, the term storm-proofing describes a process which involves the following elements:

1. An audit of potential sediment sources along a road is conducted. A trained observer walks the road segment looking for actual or potential occurrences of erosion, slippage, mass wasting, blocked or perched culverts, or other potential sediment sources. The audits document instances of Humboldt crossings, unstable fill slopes for roads and landings, stream crossings that have high potential for culvert blockage and diversion of stream flows onto the road bed, sufficient drainage and diversion of road drainage directly into watercourses.

2. The likelihood that each identified feature will deliver sediment to watercourses is also evaluated as part of the road audit, as is the total volume of sediment that could be prevented from delivery if remedial action is taken.

3. Based on the volume of sediment saved and likelihood of delivery, sediment sites are assigned a rating of high, medium or low priority.

4. All high and medium priority sites are then scheduled for corrective action. Corrective action typically requires an excavator, bulldozer, and one or more dump trucks to dig up and replace stream crossings, install drainage structures, remove unstable fill, alter the road bed to reduce the potential for diversion of flows onto the road surface, and the installation of rolling dips and/or water bars to route water and sediment.

5. Storm-proofing is considered complete when the specified corrective actions are complete, and the roads database and GIS system are updated to show that the subject road has been storm-proofed.

1.2.1.3. Road Construction, Maintenance, Improvements and Abandonment

1. For purposes of this Plan, a road will be considered upgraded when it is well drained and shows no signs of imminent failure (e.g., as evidenced by slumping, scarps or cracks in the road fill) which would deliver sediment to a watercourse. Actions necessary to upgrade a road include the installation of ditch relief culverts and/or rolling dips where significant downcutting of the ditch is noted and removal or stabilization of unstable fill material at sites showing signs of imminent failure which could impact a watercourse. An upgraded road, as described above meets the definition used in the Plan of “complying with the specifications described in the Handbook for Forest and Ranch Roads (Weaver and Hagans 1994.)”

2. All new roads will be built to site-specific storm-proof specifications. (See previous storm proofing discussion.)

3. New roads will not be constructed in RMZs except for crossings or when feasible alternatives that would have less environmental impact are clearly not available as determined through consultation with the appropriate agencies, and will be designed

to minimize the number of stream crossings and avoid mass wasting risk areas. Road layout will attempt to follow natural grades to help limit sedimentation, will be constructed on slopes primarily under 50%, and will be single lane (between 12 to 14 feet wide). In addition, bridges, culverts, or fords at stream crossings will provide for adequate passage of water during storm events.

4. Structures over fish-bearing streams and restorable fish-bearing streams for all new roads will be designed to provide for unimpeded fish passage. This could involve use of bottomless or baffled culverts, bridges, or other such structures. Where culverts are used they will be installed at an appropriate gradient, be sized to permit passage of a 100 year recurrence interval flood, and will contain downstream storm proofing of the stream bed to ensure that they are passable, and to prevent culvert "perching." Fish passage will be ensured by adhering to guidelines for culvert installation by NMFS, or by agency review of alternate installation measures.

5. Road or landing construction or reconstruction shall comply with applicable state and federal laws and shall not occur during periods of measurable precipitation (excluding fog drizzle or drip) and shall not resume thereafter until and unless soil moisture conditions are not in excess of that which occurs from normal road watering or light rainfall such that the construction or reconstruction activities will result in the loss of soil materials in amounts that will cause a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse). During each winter period (which for these purposes shall be between November first of each year and April first of the following year) no more than 2.5 miles of new road construction and 5 miles of reconstruction or storm-proofing shall occur on the Plan Area unless such additional work is approved after consultation with NMFS, USFWS, and CDFG. PALCO and the agencies shall reevaluate these winter mileage limitations during the first three years of plan implementation to determine their effectiveness. If modifications are deemed appropriate, PALCO and the agencies shall meet and agree on any necessary changes.

1.2.1.4. Road Inspections

1. All open (i.e., non-abandoned) roads will be inspected at least yearly,
2. Roads will be inspected during the winter period incidental to normal operations and note all occurrences of road slippage, erosion or impending mass failure, blocked culverts, and failures or erosion control measures.
3. Any maintenance needs identified by inspections will be performed by the end of the field season following the inspection.

1.2.1.5. Wet Weather Road Use Restrictions

Truck hauling, road grading, road rocking, or other non-emergency road use activities shall comply with applicable federal and state laws and shall cease when the activities result in a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse). Once these activities have ceased due to the foregoing conditions, these activities shall not resume until and unless soil moisture conditions are not in excess of that which occurs from normal road watering or light rainfall such that use will result in the loss of surface materials from the road in amounts that will cause a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse).

1.2.2. HCP Measures for Timber Operations

PL's HCP measures for timber operations, as they relate to aquatic resources, emphasize new management strategies for riparian forests, and development of appropriate harvest prescriptions for portions of the ownership at high risk of surface erosion and mass wasting. These measures include actions for Channel Migration Zones (CMZ), buffers along Class I and II streams, equipment limitations along Class III streams, and upslope erosion hazard management.

These measures are described below, along with an evaluation of the anticipated effectiveness of the proposed measures.

1.2.2.1. Channel Migration Zone

CMZ evaluations will be conducted as part of the DNR Watershed Assessments that are planned for each basin on the ownership. All segments of Class I and Class II streams that have a Rosgen type C, D or E channel morphology will be examined to identify the current boundaries of the bankfull channel and the remaining portion of the floodplain that is likely to become part of the active channel during the 50 years covered by the Incidental Take Permit (ITP) as evidenced by past channel migration and other field indicators. Areas not evaluated in a watershed analysis must be analyzed separately by PL using a qualified fluvial geomorphologist before any THP that includes CMZ areas can be approved. Additionally NMFS, CDF&G, USFWS, and EPA or NCRWQCB will be consulted regarding any such mapping.

The following measures will apply to Channel Migration Zones:

- Management within the CMZ will be allowed under two cases. The first case will be to enhance and facilitate riparian functions based upon a completed Watershed Analysis, and Riparian Management Plan as agreed upon by the permitting agencies. The second will be in cases of emergencies which could result in the loss of life or property, and in cases of emergencies as per agreement with NMFS, USFWS, and CDF&G. Loss of property is defined as a demonstrated high risk of loss of capital improvements such as bridges, roads, culverts, and houses, however it does not include loss of vegetation.

- No herbicides or pesticides will be used in the CMZ. Fertilizers can be used, ground application only, for erosion control purposes. Aerial application of fertilizers is not allowed.
- No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the California Forest Practice Rules (CFPRs)) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP.

1.2.2.2. Class I Stream Buffers

All fish bearing (or restorable) Class I streams as defined in the CFPRs will have a Riparian Management Zone (RMZ). The RMZ will measure 170 ft (slope distance) from the watercourse transition line as defined in the CFPRs or CMZ edge (if a CMZ is present), on each side of the watercourse. Willows will not be considered permanent vegetation for the purposes of determining the location of the watercourse transition line. The RMZ for Class I streams is divided into three management bands, the Restricted Harvest Band (RHB), the Limited Entry Band (LEB) and the Outer Band (OB). The bands are measured 0 ft to 30 ft, 30 ft to 100 ft, and 100 ft to 170 ft from the watercourse transition line as defined in the CFPRs or CMZ edge (if a CMZ is present), respectively.

Prescriptions that apply to the entire Class I RMZ are as follows:

- After each entry, PALCO will retain an additional 10 trees greater than 40 inches DBH per acre on each side of the watercourse. The trees can be counted entirely or partially within the RHB. If trees of this size are not available, the 10 largest trees in the RMZ will be retained.
- No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the California Forest Practice Rules (CFPRs)) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP.
- All portions of down wood (i.e., LWD) except as defined as slash in the FPA, or within Class I outer bands as specified below will be retained.
- Trees felled during current harvesting operations and THP approved roads construction are not considered down wood for purposes of retention.
- Felled hazard trees or snags not associated with a THP are considered down wood and are to be retained in the general vicinity.
- Trees that fall naturally onto roads, landings, or harvest units within the RMZ are considered down wood and are to be retained in the general vicinity.
- All non-hazard snags will be retained, as per the snag policy in Volume II Part M.

- The RMZ is an equipment exclusion zone (EEZ) for timber operations, except for roads and permitted equipment crossings.
- No herbicides or pesticides will be used within the RMZ. Fertilizers will be used for ground application for erosion control only. Aerially-applied fertilizers will not be directly applied to Class I RMZs.
- Full suspension yarding will be used when feasible. Full suspension is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that may deliver sediment to a watercourse to the maximum extent practicable. Where ground disturbance occurs PALCO will treat (e.g., through seeding, mulching, etc.) all sites with exposed mineral soil that can reasonably be expected to deliver sediment to a watercourse (e.g., gullies, ruts).
- Trees may be felled within RMZs to provide clearance for cable yarding corridors. Such felling will be done only as needed to ensure worker safety. In such cases, to the extent feasible given site conditions and the CFPRs, trees will be felled toward the watercourses to provide LWD. Regardless, trees felled within the WLPZ for safety purposes will be retained as down wood.
- Trees not marked for harvest which are damaged in the cable yarding corridors must be retained in place, either standing or as down wood.
- There will be a maximum of 1 entry every 20 years.

Prescriptions that apply to Class I RHB:

- Harvest to enhance and facilitate riparian functions such as canopy or LWD levels, may be allowed within the RHB based upon a completed watershed analysis and Riparian Management Plan as agreed upon (both processes) by the permitting agencies.
- Watershed analysis and/or PWA protocol (see section on watershed analysis) will be used to determine the priorities and road storm proofing standards to be used on all existing haul roads and stream crossings.
- Road segments within the RHB must be mitigated by extending the RHB on the opposite side of the watercourse from the existing road an equivalent distance of that portion of the road prism within the RHB. In the case of RMZ road crossings, the first 50 ft of road extending inland from the watercourse transition line as defined in the CFPRs (14 CCR 895.1) is exempt from this mitigation.

PL’s Late Seral, High Residual Prescriptions will apply to Class I LEB as follows:

- Only single tree selection will occur within the LEB.
- Harvest will only occur if there is a preharvest conifer basal area of 345 sq ft per acre or greater within the LEB.
- A minimum 300 sq ft post harvest conifer basal area per acre will be retained within the LEB.
- Basal area measurements will be made for conformance every 200 ft lineal segment of RMZ.
- No more than 40 percent of the conifer basal area may be harvested in a single entry.
- Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4.
- Watershed analysis and/or the PWA road storm-proofing protocol will be used to determine the priorities and road storm proofing standards to be used on all roads inside the LEB. Surface area covered in roads will be included in all calculations of basal area.

PL's Late Seral Prescriptions will apply to Class I OB as follows:

- Only single tree selection will occur within the OB.
- Harvest will only occur in the OB if there is a preharvest conifer basal area of 276 sq ft per acre or greater within the OB on each side of the watercourse.
- A minimum 240 sq ft post harvest conifer basal area per acre of OB will be retained.
- No more than 40 percent of the conifer basal area may be harvested in a single entry.
- Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4.
- Basal area measurements will be made for conformance no less than every 200 ft lineal segment of RMZ.

Table 4. Tree size and quantity necessary to meet two different residual basal area requirements.

Residual Basal Area Requirement	DBH Class	Basal Area Percent	# of Trees Per Acre*
300 sq ft/acre	6 to 12"	5%	34
	12 to 18"	10%	24
	18 to 24"	15%	19
	24 to 30"	15%	11
	30 to 36"	15%	8
	36 to 42"	20%	7
	42 to 48"	20%	5
	over 48"	0%	0
240 sq ft/acre	4 to 8"	3%	37
	8 to 12"	4%	18
	12 to 16"	8%	18
	60 to 20"	10%	14
	20 to 24"	12%	11
	24 to 28"	12%	9
	28 to 32"	15%	7
	32 to 36"	18%	7
	36 to 40"	18%	5
	over 40"	0%	0

* Retention requirements are based on basal area not tree number. Number of trees/acre provided for information purposes only.

- In areas with slopes <50 percent portions of downed wood (i.e., LWD) can be removed from the OB. That is, if a tree originating in any of the 3 Bands falls, portions in RHB and LEB must be retained onsite in place, but the portions in the OB can be removed for slopes <50%.

- In areas with slopes 50 percent or greater, all down wood (i.e., LWD) except as defined as slash in the FPA must be retained.

1.2.2.3. Class II Stream Buffers

All non-fish bearing (Class II) as defined in the CFPRs streams will have a Riparian Management Zone (RMZ). The RMZ of Class II streams will measure 100 ft (slope distance) from the watercourse transition line as defined in the CFPRs or CMZ edge (if a CMZ is present), on each side of the watercourse. Willows will not be considered permanent vegetation for the purpose of determining the location of the watercourse transition line. The RMZ is divided into two management bands, the Restricted Harvest Band (RHB), and the Selective Entry Band (SEB), which are measured from the watercourse transition line as defined in the CFPRs or CMZ (if a CMZ is present), 0 ft to 10 ft, and 10 ft to 100 ft, respectively.

Prescriptions that apply to the entire Class II RMZ are as follows:

- No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the CFPRs) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP.
- All portions of down wood (i.e., LWD) will be retained, except as defined as slash in the CFPRs.
- Full suspension yarding will be used when feasible. Full suspension is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that may deliver sediment to a watercourse to the maximum extent practicable. Where ground disturbance occurs PALCO will treat (e.g., through seeding, mulching, etc.) all sites with exposed mineral soil that can reasonably be expected to deliver sediment to a watercourse (e.g., gullies, ruts).
- Trees felled during current harvesting and approved THP roads construction are not considered down wood for purposes of retention.
- Felled hazard trees not associated with a THP are considered down wood and are to be retained in the general vicinity.
- Trees that fall naturally onto roads, landings, harvest units are considered down wood and are to be retained in the general vicinity.
- Trees not marked for harvest may be felled within WLPZs to provide clearance for cable yarding corridors. Such felling will be done only as needed to ensure worker safety. In such cases, to the extent feasible given site conditions and the CFPRs, trees will be felled toward the watercourses to provide LWD. Regardless, trees felled within the WLPZ for safety purposes will be retained as down wood.
- Trees damaged in the cable yarding corridors must be retained in place.

- The RMZ is an EEZ for timber operations, except for roads and permitted equipment crossings.
- No herbicides or pesticides will be used within the RMZ. Fertilizers will be used for ground application for erosion control only. Aerial fertization will be excluded from Class II RMZs.

Prescriptions that apply to Class II RHB:

- Management to enhance and facilitate riparian functions such as canopy or LWD levels may be allowed within the RHB based upon a completed watershed analysis and Riparian Management Plan as agreed upon (both processes) by the permitting agencies.
- If the 10 ft line falls anywhere on a tree bole, the tree is to be retained as part of the Restricted Harvest Band.
- Watershed analysis and/or the PWA road storm-proofing protocol will determine the priorities and road storm proofing standards to be used on all existing haul roads and stream crossings.
- Road segments within the RHB, must be mitigated by extending the RHB on the opposite side of the watercourse as the existing road an equivalent distance of that portion of the road prism within the RHB. In the case of RMZ road crossings, the first 15 ft of road extending inland from the watercourse transaction line as defined in the CFPRs (14 CCR 895.1) is exempt from this mitigation.

PL's Late Seral Prescriptions will apply to Class II SEB as follows:

- Only single tree selection will occur within the SEB.
- Harvest will only occur in the SEB if there is a preharvest conifer basal area of 276 sq ft per acre or greater within the SEB.
- A minimum 240 sq ft post harvest conifer basal area per acre of SEB will be retained.
- No more than 40 percent of the conifer basal area may be harvested in a single entry.
- Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4.
- Basal area measurements will be made for conformance no less than every 200 ft lineal segment of RMZ.

- Basal area measurements will be made for conformance every 200 ft lineal segment of RMZ.

- There will be a maximum of 1 entry every 20 years.

- Watershed analysis and/or PWA protocol will be used to determine the priorities and road storm proofing standards to be used on all roads inside the LEB. Surface area covered in roads will be included in all calculations of basal area.

1.2.2.4. Class III Stream Buffers

Class III streams will have three management categories based on percent slope, <30%, 30% - 50%, and >50%.

The following measures will apply to all Class III streams:

- There will be no removal of any portion of down wood within the ELZ/EEZ except for emergencies as per agreement with NMFS, USFWS and CDFG in accordance with the approved HCP.

- Trees felled during current harvesting and approved THP roads construction are not considered down wood for purposes of retention.

- Felled hazard trees not associated with a harvesting operations or road construction are considered down wood and are to be retained in the general vicinity.

- Trees that fall naturally onto roads, landings, or harvest units are considered down wood and are to be retained in the general vicinity.

- No fire ignited within the equipment limitation zones (ELZs) or EEZs.

The following measures will apply to Class III streams with slopes <30 percent:

- Equipment Limitation Zone (ELZ) extending 25 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less.

- Stabilize skid trails as per the CFPRs (Section 916.7) or as per an approved THP.

- Ground based equipment in the ELZ is acceptable if less resource damage will occur by operating in the ELZ, as per an approved THP.

- Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to the preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.

The following measures will apply to Class III streams with slopes 30 -50 percent:

- ELZ extending 50 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less.
- Stabilize skid trails as per the CFPRs (Section 916.7) or as per an approved THP.
- Ground based equipment in the ELZ is acceptable if less resource damage will occur by operating in the ELZ, as per an approved THP.
- Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.

The following measures will apply to Class III streams with slopes >50 percent:

- EEZ (Equipment Exclusion Zone) extending 100 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less.
- Ground based equipment in the EEZ is acceptable if less resource damage will occur by operating in the EEZ, as per an approved THP.
- Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.

1.2.2.5. Hillslope Management

The Hillslope Management-Mass Wasting process applies to all portions of PL's ownership, including inside the RMZs. The prescriptions in the RMZs for mass wasting will not be less restrictive than the riparian prescriptions developed as part of the interim or default strategies or through watershed analysis as appropriate and applicable to this Plan. [Note: Specific language identifying when geologic review is required and the appropriate geologic determination before alternate prescriptions can be used are still being discussed with the agencies. In the interim PL will use the following standards.] PL will not harvest or construct new roads in portions of its ownership with an "extreme" mass wasting potential, in inner gorges, headwall swales, or unstable areas without a geologist's report recommending alternative prescriptions that are approved by CDF. The professional registered PL geologist shall assess the influence of the proposed operation on the risk of hillslope failure. In areas where the potential for mass wasting is rated as "very high" or "high," PL will not operate heavy equipment off of existing roads or construct new roads, without a geologist's report recommending alternative prescriptions that are approved by CDF. The geologist's written report must accompany the THP when submitted for review. For portions of the ownership lacking geology and soils maps necessary to make a determination of risk, PL is responsible for providing site specific risk ratings based on review by a geologist. In most cases such determinations will be done as part of the THP approval process.

NMFS, CDFG and EPA or Regional Water Quality Control Board shall be notified of all THPs that are being submitted on areas of extreme, very high and high mass wasting potential in addition to inner gorges, headwall swales, and unstable areas, if the proposed operation goes beyond the default prescriptions. A registered geologist shall assess the influence of the proposed operation on the risk of hillslope failure and prepare a written report. If required (i.e., if prescriptions other than the defaults are being proposed), the geologist's report along with the THP will be sent to NMFS, CDF&G and either EPA, or the Regional Water Control Quality Board upon THP submission. If the notified agencies have concerns regarding the harvest proposal related to the risk of mass wasting, they may communicate such concerns to the RPF and CDF within 30 days of receipt of materials from PALCO or until the close of the public comment period, whichever is longer. As mandated under the FPA, CDF, as lead agency for THP review, will consider all input and determine whether the mass wasting mitigation measures contained in the THP will avoid significant impacts.

PL will treat all sites of exposed mineral soils, resulting from forestry activities within watercourses protection zones that are equal to or greater than 100 sq ft, or areas less than 100 sq ft which are on slopes greater than 30 percent if the site can deliver fine sediment to watercourses. Exposed mineral soil treatments can include revegetation or other erosion control measures including, but not limited to, seeding and mulching. Watercourse crossings will also be treated to avoid or minimize sediment delivery, using watershed analysis and/or road storm proofing protocols and road armoring standards to be used on all such crossings. Cable corridors (cable roads) that divert or carry water away from natural drainage patterns or channelize run-off that reaches watercourses will have waterbreaks installed at intervals as per the CFPRs (14 CCR 914.6).

1.2.2.6. Burning

PL will continue to manage prescribed burns (including brush piling, fire breaks, ignition techniques, prescriptions for environmental conditions permitting ignition, etc.) to minimize adverse effects. Mitigation may be required for fire management, including suppression and rehabilitation efforts, if PL or its agents are found in violation of, or out of compliance with, their burning permit. Additional prescribed burning practices may be identified during the watershed assessment process.

A variety of conditions and management techniques act to limit the risk that prescribed fires will enter WLPZs. The maintenance of 300/240 square feet of conifer basal area in the Class I WLPZs and 240 square feet of conifer basal area in the Class II WLPZs will result in a significant difference in microclimate between the burn area and the WLPZs. This will result in the following benefits with regard to minimizing the escape of controlled burns into the WLPZs.

- FUEL MOISTURE The difference in microclimate causes a difference in fuel moisture (i.e., higher moisture levels will be present in the riparian zone), due to the reduction in fuel moisture evaporation caused by the canopy.

- FUEL LOAD By minimizing the harvest within these WLPZs, the amount of slash remaining following harvesting operations, and thus the fuel level, is reduced in comparison with the area to be burned.

- LIVE VEGETATION These enhanced WLPZs usually have a diverse understory composed of live understory vegetation including herbaceous plants and woody shrubs. Generally, there is much more of this live vegetation in a WLPZ, which is resistant to burning, than in the burn area. This reduces the likelihood that a fire will migrate into the WLPZ.

Due to the above factors, the likelihood of an escape into the WLPZ is minimized, and the likelihood of continued burning toward the watercourse if a fire does escape is further reduced

In addition to the benefits provided by the retention standards, the following measures are used, when appropriate and feasible:

- No fire ignition in WLPZ, EEZ, or ELZs is conducted. This results in a fire which backs its way toward the WLPZ, while the head fire proceeds up the hill. Backing fires are slower than head fires. This reduced rate of fuel consumption reduces the likelihood of escape.

- Where, due to topographic features and/or fuel patterns, the likelihood that a fire lit on both sides of a WLPZ would result in intrusion into the WLPZ, this potential is mitigated by igniting one side of the WLPZ at a time.

- Burning is limited to spring and fall when fuel moisture conditions, relative humidity, fuel loading and atmospheric conditions such as wind are conducive to controlled burning.

- Fuel breaks are established to the extent necessary to control burning. Fuel breaks in WLPZs will generally be avoided but some hand clearing may be conducted to prevent and control escaped fires. Fuel break clearance within WLPZs will be kept to a minimum. No overstory removal will be undertaken. If areas of bare soil are exposed that could result in fine sediment inputs, such areas will be treated as provided above in section 1.2.2.5.

- In areas where use of equipment is feasible and appropriate, piling of slash for burning at a later date is used, minimizing the potential for fire escape.

- Burns are conducted pursuant to permits issued by CDF.

- Burn permits generally specify minimum manpower requirements for controlling fires.

- Whole tree yarding reduces fuel loading and is conducted when feasible.

A helitorch (i.e., a helicopter based igniting system) is used, when available and feasible, for safety of personnel. Helicopter ignition proceeds more rapidly than hand ignition, and this rapid ignition can be used to control the direction and speed of the burn. In addition, helicopters used for burning are also equipped with a bucket to drop water on areas where escapes occur.

1.2.3. HCP Mitigation Measures for Rock and Gravel Mining

Rock Quarrying

As stated in a previous section, PL is aware of few impacts on creeks or riparian areas as a result of hardrock mining on the property. Active quarries are generally located away from stream channels. Any future quarries are expected to be similarly located in upslope areas. All borrow pits will be monitored when active and at least once per year when inactive to determine if there exists or there is potential for aquatic impacts in the form of fine sediment or mass wasting sediment delivery to streams. If quarry conditions are such that visible increases in the turbidity of Class I, II or III streams will occur, mitigation measures will be implemented. As appropriate, mitigations may include but are not limited to, wet weather operating limitations, installation of sediment control structures, limitations on overburden placement and distribution, removal of spoil material, revegetation and abandonment. Borrow pits will not be established in RMZs. Mitigations will be developed in consultation with the agencies.

The quarries and surrounding areas will be analyzed further during the watershed analysis process. This will provide the company with an opportunity to identify any necessary future mitigations at that time. In addition, quarries located within or adjacent to marbled murrelet Conservation Areas will be operated to minimize activities during the murrelet breeding season to the maximum extent practicable.

Near Stream Gravel Mining

Mining is already highly regulated by several agencies. Therefore, no new HCP measures are proposed here. The conclusion that no additional mitigation measures are needed is supported by NMFS issuance of an Incidental Take Statement covering PL gravel extraction operations.

In-stream damage due to gravel extraction is mitigated by removing gravel using the gravel bar skimming method. This technique removes a fairly uniform layer of gravel from the surface of the bar by use of equipment such as a front-end loader or a paddle-wheel scraper. Skimming occurs at successive depths and along contiguous strips generally maintaining similar contours of the bar. The process creates a reasonably smooth finished surface in conformance with the natural bar topography at slightly lower elevations while allowing the maintenance of slopes towards the river or in the downstream direction to avoid fish stranding or other adverse river impacts. Other mining methods may be recommended or used only after consultation with the appropriate review and responsible resource agencies.

Impacts to riparian zones are minimized by trucks using only established road corridors to access the mining areas. In the case that proposed activities would disturb riparian vegetation, the area would require additional delineation (mapping), identification, description and proposed mitigation measures. This generally requires input from a qualified botanist. Such information is then subject to review by the County of Humboldt Extraction Review Team (CHERT) and by the various permitting agencies (CDFG, COE, Humbdolt County) which may or may not approve such plans. If proposed mitigation is not deemed adequate, then extraction plans may be altered to achieve avoidance. In addition to this case by case mitigation, ongoing mitigation is guided by the COE letter of permission (LOP). The COE LOP process includes monitoring procedures and success standards for mitigative revegetation. In essence, mitigative revegetation may need to be monitored over the course of several seasons, as provided to achieve success.

1.2.4. HCP Mitigation Measures for Grazing

As noted in Section 1.1.4, grazing on PL's lands has little impact on streams. This is true because grazed lands are relatively rare on the ownership, and are located in discrete patches, often on ridgetops away from streams. In addition, cattle stocking levels are kept low, and many of the parcels used for grazing on the ownership contain fences or features that limit cattle access to riparian areas. Importantly, ranchers using PL's lands usually try to keep their livestock away from the wet areas due to the difficulty of herding the animals in the spring and fall. It is much more difficult to account for the herd if it has been allowed to access the timber or riparian areas that are adjacent to their grazing area. Ranchers are also concerned that when livestock do access creeks there is a good chance of them falling into deep holes that are created along the steep gradient channels resulting in death or serious injury. Ranchers limit cattle access to streams via fences, and by locating salt and developed watering facilities up in pastures to lure the cattle away from riparian areas.

Given the low impact of grazing currently seen on PL's lands, the company is proposing no new mitigation measures for grazing as part of this Plan. However, grazing in specific watersheds will be evaluated as part of the watershed analysis process. If watershed evaluations indicate that grazing is having an adverse effect on aquatic resources, additional mitigation measures will be utilized during the prescription writing phase of watershed analysis. Mitigating prescriptions that could be implemented based on the results of watershed analysis include: fencing of streams to prevent access, rotation of periods of grazing with periods of rest, provision of alternate sources of water (other than watercourses) and cesation of all grazing activity. PL will limit grazing in the Plan Area to no more that 1,000 head at any one time during the Plan period. Grazing in specific watersheds also will be evaluated as part of the watershed analysis process. Prior to that analysis, PL will prepare topographic maps showing the specific location of the grazing areas in relationship to streams and drainages and will provide copies of the maps to NMFS, USFWS, and CDF&G.

1.2.5. HCP Mitigation Measures for Instream Habitat Improvements

As outlined in this Section 1.1.5, extensive mitigation measures are already "in place" to reduce short-term impacts associated with stream restoration activities including:

- Moving fish away from construction sites

- Keeping heavy equipment out of the stream unless necessary and then limiting work to summer months (i.e., July 1 - October 1)
- Suitable large woody debris removed from fish passage barriers that is not used for habitat enhancement projects will be left within the riparian zone.
- Keeping equipment clean of diesel and oil and having petroleum product absorbent material at the work site
- Re-establishing riparian vegetation where it has been disturbed
- Seeding and straw-mulching bare soil
- Installing silt catchment fences during construction
- Restoration sites will be revisited at least once 3 years after installation to assess effectiveness

Given the strongly positive effects of instream restoration, any short-term negative impacts are both minor and acceptable. Therefore, no additional mitigation measures are proposed for the instream fish habitat improvement as part of this Plan.

1.2.6. HCP Mitigation Measures for Fish Rearing Facilities

As noted in this Section 1.1.6, PL's fish rearing facilities are being used, and will continue to be used, primarily to aid in the establishment of self-sustaining populations of wild fish. Thus, the facilities will only be used as long as they are thought to be having a positive impact on wild fish populations. To increase the chances that the overall effect of the facilities is positive, PL has depended in the past on guidance from fisheries biologists within CDF&G to determine the best operational methods. This cooperation/collaboration has extended to yearly review of the facilities operations, adoption by PL of CDF&G recommended operation and release schedules, and releasing hatchery fish into stream reaches that had been improved through the State-PL cooperative program in stream restoration (see Section 1.1.6). By keeping the scale of operations low, depending on wild fish for eggs/milt, and limiting adult captures and juvenile releases to a single basin (Yager Creek), the company has assumed the potential negative impacts of its program have been minimal and more than compensated for by the positive effects of fish rearing. In addition, PL has agreed that no coho salmon or other listed species will be collected for use in any fish hatchery activities unless PL obtains a federal 10 (a) 1(A) permit for this/these species.

Much recent research on hatcheries has been conducted, in large part as a result of the extensive hatchery releases being used in the Columbia River basin. These studies have identified many potential problems with hatcheries that could actually result in a net negative impact to wild fish (see this Section 1.1.6). Many of these impacts apply to very large hatcheries that release fish with the explicit goal of increasing sport/commercial harvest. PL's facility operates with a restoration goal, so it is not clear to what extent these studies apply to the company's operations. Regardless, the increased focus on the potential negative impacts of hatcheries has led the company to assess what it can do to ensure a net positive impact on wild fish. The company's fish rearing facilities will minimize risks if they are managed using practices that minimize genetic and behavioral changes in artificially produced fish. PL is currently using a series of measures to meet this goal and is proposing to begin using several more:

- To reduce the potential for directional genetic changes and loss of local adaptation, adults should be collected throughout the run to represent the entire return in size, age and other phenotypic characters of adaptive value (Nickelson, et al. 1986). PL currently attempts to collect fish from throughout the spawning run and will continue to do so in the future.
- Only wild fish should be used for eggs/milt. To accomplish this goal, all fish released from the fish rearing facilities must be marked (e.g., fin clipped) so that they can be separated from wild fish. PL has been using these measures for several years and will continue to do so in the future.
- During artificial propagation mating should be done at random. Mating designs include single pairs or single females with double or triple males, to reduce the risk of loss to sterile males, and to increase gene mixing. PL has used this procedure for years and will continue to do so in the future. Marking will not be conducted when hatchery fish are released as fry.
- Although studies on genetic differentiation within and among drainages often shows that fish from different drainages do not have statistically different genetic markers (e.g., protein allozymes), gene diversity analysis and life history suggest that fish from different drainages should be considered as different populations (Reisenbichler, et al. 1992). Thus, juvenile fish should only be released into streams and drainages from which the eggs/milt were collected, that is, "interbasin transfers" should be avoided (Reisenbichler and McIntyre 1986, Steward and Bjornn 1990). PL has followed this procedure and will continue to do so in streams that contain more than vestigal numbers of wild fish.
- Some streams on PL's ownership do not contain wild fish, or contain so few that it would not be possible to collect sufficient wild fish to produce juveniles with the fish rearing facilities. For many of these streams, PL plans to work cooperatively with the NMFS and CDF&G to develop plans to reintroduce fish. Such reintroductions would require interbasin transfers, but the company will limit transportation (outplanting) of fish to areas that are known or thought to have contained genetic strains of fish similar to those being outplanted as recommended by Flosi et al. (1998).
- Release timings and locations are important in reducing negative interactions between wild and hatchery fish (Nickelson, et al. 1986). Fish releases should attempt to mimic natural outmigrations and the release size of the artificially produced juveniles should be similar to wild juveniles of equivalent age. Although PL has routinely released

most fish at times and sizes comparable to those for wild fish, this is not always the case (e.g., chinook salmon released in October-November). Future smolt releases will be conducted at times consistent with the normal migration period for wild fish. Control of size is more difficult since hatchery fish grow faster, and will, therefore, be larger if released coincident with wild fish outmigration. However, operations will be modified, to the extent possible, to minimize size differences between hatchery and wild fish as well.

- To avoid transmission of diseases and parasites to wild fish, PL will conduct aggressive disease control that is in accordance with CDF&G policy. Diseases must be considered in outplanting programs because it is a major cause of mortality in hatchery fish and hatchery fish can be disease vectors

- One of the most promising techniques to reduce genetic and competitive impacts on wild fish may be to release fry or young juveniles from fish rearing facilities instead of smolts. By releasing hatchery fish at a very early age, they will be exposed to the same stream environment, and therefore most of the same selective pressures, as wild fish. Yet by using the very high survival to emergence rates of eggs in hatcheries, PL can use its fish rearing facilities to produce much larger numbers of fry than might otherwise occur under natural reproduction only. PL, working with the NMFS and CDF&G, intends to expand the use of fry/early juvenile releases in the future in conjunction with science research projects to document the success of this technique. If these studies indicate that fry/early juvenile releases are successful, such releases may eventually represent most or all of the company's fish rearing program.

- PL intends to continue the association between fish rearing and instream/upslope restoration activities. As habitats are improved and fish access is provided, PL expects that it will have many stream habitats that are not utilized by wild fish, or are underseeded. In many cases wild fish may not be able to successfully colonize such areas within a reasonable time period (Hard et al. 1992). Releases of artificially reared fish will be targeted to such areas when possible.

- PL’s fish rearing operations are not meant to continue indefinitely. As wild fish populations on the ownership become more widespread and self-sustaining, PL will reduce, and eventually eliminate its fish rearing program. Reductions and termination of the program would be conducted only after consultations with the NMFS and CDFG.

1.2.7. Scientific Surveys and Monitoring

PL already has a significant trends monitoring program in place on its lands. The company has installed 52 permanent sampling stations. Additional monitoring sites will be added in the future as discussed in Section 2.2. At each station aquatic macroinvertebrates, fine sediments, substrate size and canopy cover are measured. In addition, stream bed surveys and measurements of continuous temperature and large woody debris are conducted at a subset of the 52 stations.

Although not currently a part of PL's trends monitoring program, PL intends to collect data on fish abundance, turbidity, and discharge in the future. For fish, PL will establish a number of survey reaches across the ownership.

1.2.8. Headwaters/Elk Springs Land Transfer

This agreement calls for government acquisition of 5,600 acres of Pacific Lumber's property, including two old growth forest stands; nearly 3,000-acres for the Headwaters grove and the more than 400-acre grove at Elk Head Springs including associated buffer zones. With the addition of other property, the Agreement would ultimately create a 7,500-acre nature preserve. The Agreement also includes approval of two documents that apply to future forestry and wildlife activities on Pacific Lumber's land. The federal government must approve a Habitat Conservation Plan (HCP), and the State of California must approve a long-term Sustained Yield Plan (SYP). In exchange for transferring 5,600 acres of its property to the state and federal governments, Pacific Lumber would receive a compensation package that includes approximately 7,700 acres of adjacent, lower-value timberland and approximately $300 million of cash and other considerations. Conversion of this land to a preserve will significantly reduce the expected activity levels and, therefore, impacts to these areas.

1.2.9. Watershed Analysis

The Pacific Lumber Company will conduct watershed analysis on all of its ownership. These watershed analyses will subsequently be reviewed and updated as needed so that they remain "current" for the life of the permit. The company is currently working under an "interim" strategy which, although very strong, is a "one size fits all" approach. The benefit of completing watershed analysis on PL land is that the management strategies can be tailored to the environmental factors and current influences that shape each watershed. Due to the geologic diversity and a more than 100 year history of activity on the ownership, a variety of circumstances exist on the land. Examples include old and new roads, stable and unstable areas, and forest stands of varying ages and conditions. After watershed analysis is completed, specific prescriptions can be implemented that will maintain and/or enhance the aquatic environment based on the current conditions and the future needs identified in that area.

PL expects that watershed analysis will result in site specific management prescriptions. Consequently, it can be used to modify some or all of the interim aquatic prescriptions described in this document. The general approach and extent to which the interim strategy described here can be modified by watershed analysis is detailed in a "framework document" from the Federal Agencies to PL dated 3 February 1998 (Section 4 of this HCP). [Note: The Pre-Permit Agreement in Principle modified the team composition and work plans of the framework document.] The framework document, for example, specifies the level of detail of the analysis, the review and approval process, and the interval until updating of the watershed analysis is required (Section 4). The framework also sets specific upper and lower limits (referred to as maximum and minimum sideboards, respectively) to the range of possible prescriptions that can result from watershed analysis. The maximum limits include:

- A 170' and 130' (horizontal distance) RMZ along each side of all Class I and Class II watercourses, respectively.

- A 30' and 10' restricted harvest or "no-cut" band along the inner width of all Class I and Class II watercourses, respectively.

- The RMZ extending from 30' to 170' along either side of all Class I watercourses will have restrictive harvest practices up to and including complete exclusion of all harvest.

- The RMZ extending from 10' to 130' of all Class II watercourses will similarly have restrictive harvest practices that can include exclusion of all harvest.

- A mass wasting avoidance strategy will be implemented in all areas containing an extreme, very high, or high risk of mass wasting. The avoidance strategy will follow that outlined in the 7 January 1998 Interagency Aquatic Strategy (Section 3) as modified during pending agency negotiations. As currently written, maximum prescriptions for these areas can extend up to and include exclusion of all harvest and road building.

The minimum limits include:

- RMZ buffers set equivalent in width to those required by the California Forest Practice Rules in effect at the time (currently 75-150 ft. on Class I watercourses and 50-100 ft. on Class II watercourses)

- A 30 ft. and 10 ft. "no cut" band along the inner edges of all Class I and Class II watercourses, respectively.

- Remaining portions of RMZs would be managed using the California Forest Practices Rules.

PL, at its discretion, may exceed the maximum limits contained in this agency framework, but, as agreed to by the agencies, cannot be compelled to do so. Circumstances where PL may agree to exceed the maximum limits could include: 1) when scientific studies conducted as part of the watershed analysis identify management related erosion or mass wasting hazards not fully protected by the maximums, 2) when one or more aquatic resources of special biological value is present within a watershed, or 3) in response to new studies or data that clarify how best to protect one or more aquatic species.

PL will endeavor to complete watershed analysis on all its lands within 3 years of the issuance of the ITP. The Analysis will be performed using a modified version of the Washington Forest Practices Board Manual: Standard Methodology for Conducting Watershed Analysis – Version 4.0 November 1997 ("Washington Department of Natural Resources methodology") or the most current version at the time of analysis. This methodology is the most widely used assessment method in the PNW. It is also widely recognized as a replicable and scientifically based method.

Modified versions of the Washington DNR methodology have been approved by the Fish and Wildlife Service and NMFS in other multi-species habitat conservation plans (e.g., Plum Creek HCP). The methodology is a dynamic one; "Periodic revision and incorporation of new methods and insight is a fundamental assumption of the diagnostic approach upon which this manual relies (page iii)." In keeping with the Feb. 3 framework, PL will collaborate with state and federal agencies to both modify the methodologies of this manual so it will take into account California's conditions and requirements and in the implementation of the watershed analysis. A PL-Agency team has already been organized for this purpose.

PL's watershed analysis will consist of eight parts or "modules": mass wasting, surface erosion, riparian function, stream channel, fish habitat, amphibians and reptile, synthesis and prescription setting. Watershed analysis will also include a cumulative effects analysis to supplement the CE evaluation embedded within PL's monitoring program (see section 2.2.4). Riparian function, in turn, has two components, LWD and shade/riparian. After each is looked at separately, closely related sections are then compared (i.e., fish habitat and stream channel modules). Based on these steps, linkages between management activities and stream/fish vulnerabilities are identified. Once these linkages are recognized, a prescription can be developed to break the linkages and evade the negative impact. The strength of this system is that prescriptions are developed for specific cause-effect linkages. A brief description of methods to be used for each module is presented below:

The methodologies in the module for assessing mass wasting are very similar to those used by Pacific Watershed Associates (PWA) for the assessment of Lower Eel River for the EPA and the survey of Bear Creek for PL (PWA 1998A, 1998B). Briefly, these methods involve looking at successive years of aerial photographs to identify the type and location of major natural and management-related sources of sediment production, estimate the area and/or volume of sediment delivery, and stratify the study area into appropriate sub-watersheds. Aerial photo review will be followed by limited field verification. Pyles et al. (1998) indicate that this type of study can significantly underestimate natural rates of mass wasting (and by extention to overestimate management impacts on mass wasting rates). However, it still represents the best approach available to PL to assess landsliding on its lands in the near term. PL's upslope monitoring (see section 3.2) will provide a more systematic sampling design for landslide occurrence in the long-term.

The module for surface erosion from roads will be replaced by the methods that were used by PWA for the surveys of Freshwater and Bear Creek Watersheds (PWA 1998). Roads are surveyed to identify all past erosion and sediment delivery as well as sites of expected erosion and sediment delivery. Upon identifying past erosion, the dimensions, cause, approximate age, and estimated sediment delivery are determined for each site. Estimates of these parameters are also made for sites of potential activity that have the capacity to deliver sediment to the stream channel. Surface erosion from non-road areas will also be assessed according to the DNR methodology as modified.

The riparian function assessment focuses on two specific processes – recruitment of LWD to the stream channel and shade for aquatic systems. Information for both processes are largely collected from aerial photographs with some field verification. With respect to LWD recruitment, vegetation adjacent to the CMZ is surveyed from aerial photographs of each watershed. The width of the area surveyed is dependent on the type, size and/or density of the vegetation. For the shade component, the percent of stream channel exposure is assessed. In addition to this information to be collected, the company has limited historic data on instream LWD and canopy closure. This module requires examination of Class I (i.e., fish-bearing) creeks and any streams that contribute 20 percent or more of flow of any Class I stream. PL will survey additional Class II stream reaches to better take into account the needs of amphibians (e.g., tailed frog, southern torrent salamander). The details of these additional surveys of Class II streams will be developed with the agencies during the modification of the DNR method to conditions in California.

There are four main components to the stream channel module. 1) Stream channels are classified by their confinement and gradient into channel response types and mapped. 2) Current channel conditions are assessed using time series analysis of aerial photographs and limited field visits. 3) Channel sensitivities to input factors are identified so conditions likely to influence channel morphology can be predicted. 4) The ability of the stream channel to develop fish habitat conditions is then assessed.

Both past and present conditions are taken into account when assessing fish habitat conditions. The first step to the fish habitat module is to collect and evaluate existing information to describe the fisheries resource conditions in the basin and to identify information gaps. After information gaps are identified, it is then necessary to conduct a field survey to collect this new information. All existing and new information is evaluated to identify and qualify habitat conditions in the basin. This evaluation will identify fish distribution (historic and present), areas of existing or potential habitat use, and areas of habitat "need." The stream habitat survey information collected by California Department of Fish and Game for many reaches on PL's ownership will provide a base for the data needed in this module.

The amphibian and reptile portion of the watershed analysis mainly consists of extending the riparian module upstream. In addition to the riparian information, habitat conditions for tailed frogs and southern torrent salamanders will be monitored. These include: water temperature, canopy cover, embeddedness, large woody debris, and stream gradient. Procedures are discussed in greater detail in the monitoring section of this document. The module will identify both current conditions relative to the habitat needs of selected amphibians and reptiles, and habitat needs that should be addressed during prescription setting. Because foothill yellow-legged frogs and northwestern pond turtle are found in larger stream systems, parameters for their habitat will be covered by the fish habitat module and monitoring.

The synthesis portion of the watershed analysis draws together all of the information collected in the above modules. From this information, cause-effect linkages are identified. These cause-effect linkages show how management activities affect the resource. The linkages are then used in the prescription module.

Prescription setting is done by a team composed of foresters, geologists, agency employees and scientists from the analysis team. This team will work to develop prescriptions to "break" the cause-effect linkages. In other words, this process will evaluate how management activities can be modified to prevent negative impacts on the resource. Ideally, the team will identify more than one approach, when possible. These alternatives can then be evaluated based on their likely effectiveness as well as the costs involved. PL will submit the selected prescriptions to the agencies for their review. If approved by the agencies PL will apply the resulting prescriptions to the watershed.

A pilot watershed analysis will be conducted in Freshwater Creek this summer (1998). It is anticipated that a watershed analysis of the Elk River basin will follow next year. Throughout this process, the company will work closely with state and federal agencies to set priorities for work completion, to modify methodologies for our area, and to analyze the information collected for the watershed studies. This collaboration will be especially important during the pilot study in Freshwater Creek as methodologies are being worked out. Qualified scientists and technical staff will conduct all assessment work.

The watershed analysis process will be open for public comment. There will be a presentation to the public to explain what the company will be doing with respect to each watershed analysis. The goal of this interaction is to get public input on problems and priorities. Members of the public that have the requisite technical training may also participate in the technical analysis. On completion of each watershed analysis a second meeting will be organized to present results of the watershed analysis and justifications of methodologies and prescriptions.

1.3. ANTICIPATED EFFECTS OF HCP MITIGATION MEASURES

PL has proposed to implement a large number of HCP measures to protect aquatic species and the habitats upon which they depend. Although collectively these measures are expected to have an overwhelmingly positive impact on fish and amphibians, it is sometimes difficult to quantify the benefit of individual mitigations. This is so because: (1) PL conducts a variety of management actions, each of which could be affected differently by the Plan (Table 1), (2) many of the measures will affect more than one habitat or water quality related variable, and (3) different measures will affect some of the same variables possibly leading to additive or synergistic effects. Another issue in assessing the effects of the Plan involves time scales. It could take decades to fully realize many of the habitat and water quality improvements expected if the Plan is implemented. For example, riparian buffers will improve LWD recruitment in many locations. However, this improvement will require re-establishment of mature trees within riparian zones, a process that could take 50 years or more in some locations.

The discussion of impacts that follows is divided into sections corresponding to the major activities covered by this Plan. For each section the effectiveness of individual mitigation measures is discussed, with a review of supporting data and scientific studies, as appropriate. These sections are followed by an evaluation of the Plan effects on different fish assemblages (i.e., trout and salmon, and "other" fish) within streams on PL's ownership.

1.3.1. Anticipated Effectiveness of HCP Mitigation Measures for Roads and Timber Operations

Overview

Timber operations, such as harvest, yarding, hauling, road use/construction, etc. constitute the biggest potential impact of the company's operations on the aquatic resources covered by this Plan. Accordingly, the largest and most complex mitigations proposed by the company address this area. These mitigations amount to a very significant change in the way the company conducts its timber operations. The result, arguably, is the most comprehensive, and conservative, set of mitigations to protect fish and amphibians ever proposed by a private timber company as part of a HCP. Importantly, these mitigations are not being proposed by PL based on internal studies, rather this "aquatic conservation strategy" was developed in collaboration with biologists from numerous state and federal agencies including the NMFS, USFWS, EPA, CDF&G, CDF, and RWQCB. During the development of the strategy PL and agency staff studied past management practices, examined data on fish, water quality, and habitat conditions on the ownership, reviewed scores of relevant scientific studies and papers, and conducted several site visits to local streams, roads, and harvest areas. The result is a complex, scientifically based approach to protecting fish and stream habitats that is specific to the conditions on the ownership as a whole.

The aquatic conservation strategy has three phases. This multi-phased system was designed both to provide redundant protections for aquatic resources, and to ensure that the best available science was used to develop and implement the aquatic strategy. The first phase is a set of interim prescriptions that will be used immediately to ensure the company's operations have a minimal impact on fish and riparian dependent wildlife. These interim prescriptions will be replaced as the second phase, watershed analysis, is completed for the company's lands. Watershed analysis involves additional data gathering and scientific studies to determine how the "one size fits all" interim prescriptions can be modified to best accommodate site specific conditions within individual basins. Thus, the second phase will allow PL, and its agency counterparts, to develop more effective approaches to resource protection than was possible in the interim strategy. [Note: As discussed above, portions of PL's lands not assessed through watershed analysis within 3 years of issuance of the ITPs and/or that do not have site-specific prescriptions approved by the agencies will be subject to the default prescriptions contained in Section 3 as modified through ongoing negotiations]. The third phase is monitoring and adaptive management. The third phase represents an "insurance policy" designed to make sure that the conservation strategy is effective in providing protection for aquatic resources. Monitoring and adaptive management also provides a mechanism to incorporate new data and scientific studies as they become available. The discussion below details the interim aquatic mitigations, and the science used to develop them. Subsection 1.2.9, details the watershed analysis phase of the aquatic conservation strategy. Subsection 2.2 details PL's proposed approach to monitoring, cumulative effects assessment and adaptive management.

Background

Timber harvest and associated road construction have the potential to disrupt riparian ecosystem functions. For example, timber harvest along streams can alter the flows of LWD, sunlight, nutrients, and organic carbon into adjacent aquatic systems (Chamberlin et al. 1991; Bilby and Bisson 1992; Washington Forest Practices Board (WAFPB) 1994; Hartman et al. 1996). These alterations, in turn, can lead to increased air and water temperatures, channel instability, fine sediment inputs, and the loss of habitat elements (e.g., pools, side channels) important to fish (Grette 1985; Rashin and Graber 1992; Powell 1987; Holtby 1988; Ledwith 1996).

The impacts of timber operations on PL's lands are exacerbated by poor past practices. The earliest harvest involved clearcutting and burning of large areas, use of streams for transportation and yarding corridors, and extensive sediment disturbance and transport into streams. No consideration was given for site preparation or replanting of harvested stands, many of which were subjected to repeated harvest and burning as settlers attempted to convert the forests to pastures. Even with the advent of a more sustained view of timberland management, clearcutting to the edge of streams, and yarding through and across stream channels was both legal and widely practiced. Also destructive were forest practice rules that required PL to remove LWD from streams to enhance fish passage. Although some of these disturbances may have had some positive effects (e.g., recruitment of spawning gravels, removal of fish barriers) the overall impact was mostly negative. In addition, one result of these early practices is a "legacy" effect: stream channels with low instream wood levels and immature riparian vegetation, and hillslopes containing abandoned but unstable skid trails and "Humboldt" crossings.

Contemporary forest management generally relies on the use of best management practices (BMPs) to reduce the environmental impact of timber harvest and roads on aquatic systems. One of the main regulatory components of BMPs is the establishment of vegetative buffers or riparian management zones (RMZs). The RMZs are used to separate sensitive resources (i.e., streams, wetlands, critical wildlife habitat) from forest management activities. Best management practices or forest practice regulations usually require special management prescriptions within established RMZs. These prescriptions aim to preserve qualities associated with unharvested riparian zones in order to limit impacts of timber harvest and road building on the aquatic and riparian ecosystems. RMZs have been and continue to be a widely used and accepted practice to protect streams from the impacts associated with timber harvest (Hall and Lantz 1969; Erman and Mahoney 1983; Tschaplinski and Hartman 1983; Koski et al. 1984; Steinblums et al. 1984; Lynch et al. 1985; Murphy et al. 1986; Murphy and Koski 1989; Potts and Anderson 1990; Robison and Beschta 1990; USDA 1993; Osborne and Kovacic 1993; Davies and Nelson 1994; and Murphy 1995).

Although the effectiveness of RMZs as a mitigation method is well established, the width and management restrictions necessary for RMZs to protect streams is still in question. The most recent approaches to selecting RMZ strategies have emphasized retaining enough riparian vegetation to preserve most of the functional benefit of streamside vegetation including water temperature regulation, channel stability, leaf litter fall, sediment regulation, and LWD recruitment (USDA 1993). In some cases, the goal has been to produce and maintain conditions within riparian corridors approximating those in unharvested or old growth systems on the assumption that this is the best approach to ensuring continued production of aquatic biota

(Petersen et al. 1992; USDA 1993; WAFPB 1994). However, numerous studies have demonstrated that invertebrate and fish production is actually higher in harvested or partially harvested forests than in old growth systems (Hansmann and Phinney 1973; Murphy and Hall 1981; Murphy et al. 1986; Hawkins et al. 1982; Erman and Mahoney 1983; Holtby 1988; and Bilby and Bisson 1992), which strongly suggests that old growth conditions may not be optimal. In addition, RMZs wide enough to ensure development of old growth conditions over time can remove much or most of the total land area from timber production. For example, in the FEIS prepared for the Northwest Forest Plan (USDA 1994a), the study's authors applied RMZ widths advocated in the FEMAT report (USDA 1993) to nine demonstration sites. They found that up to 80 percent of the total land base of their test areas would be composed of RMZs where little or no timber harvest would be allowed.

The Endangered Species Act requires that an applicant for an incidental take permit "minimize and avoid take to the maximum extent practicable." As PL and its agency counterparts met to design the aquatic conservation strategy, both sides recognized that this practicability clause necessarily excluded any RMZ strategy that would result in significant economic harm to the company. However, both sides also understood that the resulting strategy must provide sufficient protection of aquatic resources to avoid "appreciably reducing the likelihood of the survival and recovery of the [threatened or endangered] species in the wild" (16 U.S.C. § 1539 (a)(2)(B)(iv).). The goal then was to find an aquatic strategy that would not harm the company, nor result in jeopardy to any listed species.

The search for this "dual goal" strategy was aided by a significant body of scientific research showing that many of the benefits of RMZs decrease rapidly as one moves away from the streambank or floodplain. For example, numerous studies have shown that a buffer extending from the stream edge inland 30 ft provides more large woody debris than all other portions of the buffer combined (Murphy and Koski 1989, McDade et al. 1990, Van Sickle and Gregory 1990, McKinley 1997). These studies can be used to develop an aquatic strategy that provides significant biological benefit yet does not require RMZs that would economically hurt PL.

In general, studies examining buffer effectiveness have identified two buffer widths to protect riparian function and aquatic resources: one site potential tree (e.g., USDA 1993), and 100 ft. (e.g., Lynch et al. 1985). Use of site-potential tree height (i.e., the average maximum tree height given existing site conditions) assumes that any tree close enough to reach the stream if it fell contributes to riparian function. Site-potential tree height also allows for adjustment of the RMZ size to account for local growing conditions. For example, if trees attain a maximum height of 30 m, it is unlikely that an RMZ greater than this width will result in greater inputs of LWD to adjacent streams. The selection of 100 ft as a recommended buffer width is largely an "accident" of experimental design. Many studies have included an evaluation of buffers 100 ft. wide rather than wider or narrower buffers. Thus, these studies were able to demonstrate that a 100 ft. buffer was sufficient to protect streams, but not whether a narrower buffer would have also been sufficient.

Determining the relationship between RMZ width (and prescriptions) and biological protection requires a direct review of the appropriate scientific literature. The following sections attempt to provide such an overview, but other reviews are available. For example, in their review of 38 papers associated with RMZs, Johnson and Ryba (1992) found that the RMZ widths that were prescribed varied according to resource function and author. They noted a lack of a consistent research focus, and reasoned that this, in part, explained why RMZ widths varied from 3 to 200 m. They found that prescribed widths for sediment removal and control varied from 3 to 88 m. Similarly, prescribed widths for regulation of water temperature ranged from 11 to 43 m. Belt et al. (1992) found a similar lack of consistency in RMZs in their review of regulations for four western states, California, Idaho, Washington, and Oregon. Required RMZ widths varied from a maximum of 30 m to as little as 1.5 m depending upon the state and channel type.

The National Council for Air and Stream Improvement has recently commissioned another review of the RMZ literature (Castelle and Johnson, 1998). The report examines the effectiveness of streamside vegetation in providing six riparian functions: "sink" functions-streambank stabilization, sediment reduction, chemical reduction, and "source" functions-LWD recruitment, particulate organic matter (POM) production, and streamside shade for water temperature moderation. Castelle and Johnson reported that the first 5 to 25 m of RMZ vegetation provides the most (50 - 75% effective) benefit for sediment and chemical removal. Streambank stability was not found to be a function of buffer width, but of root density within the bank. For source functions, they reported that RMZ widths of up to 25 m provide approximately 75% of LWD, POM, and shade production.

The Washington Department of Natural Resources recently reviewed RMZ effectiveness as part of its multi-species Habitat Conservation Plan (WADNR 1996). Much of their review concludes that RMZs equivalent to 40-60 percent of site potential tree height are sufficient to maintain riparian ecosystem functions important to fish and wildlife.

The remainder of this section includes PL's own review of relevant literature addressing each of the five ecosystem functions identified in the introduction: LWD recruitment, organic carbon inputs (e.g., litterfall), streamside shade for water temperature regulation, channel formation/stability, and sediment regulation. For each of the five functions a specific description is followed by a short summary that attempts to provide an overview of RMZ effectiveness in maintaining conditions suitable for the production of fish found on PL's lands.

1.3.1.1. LWD Recruitment

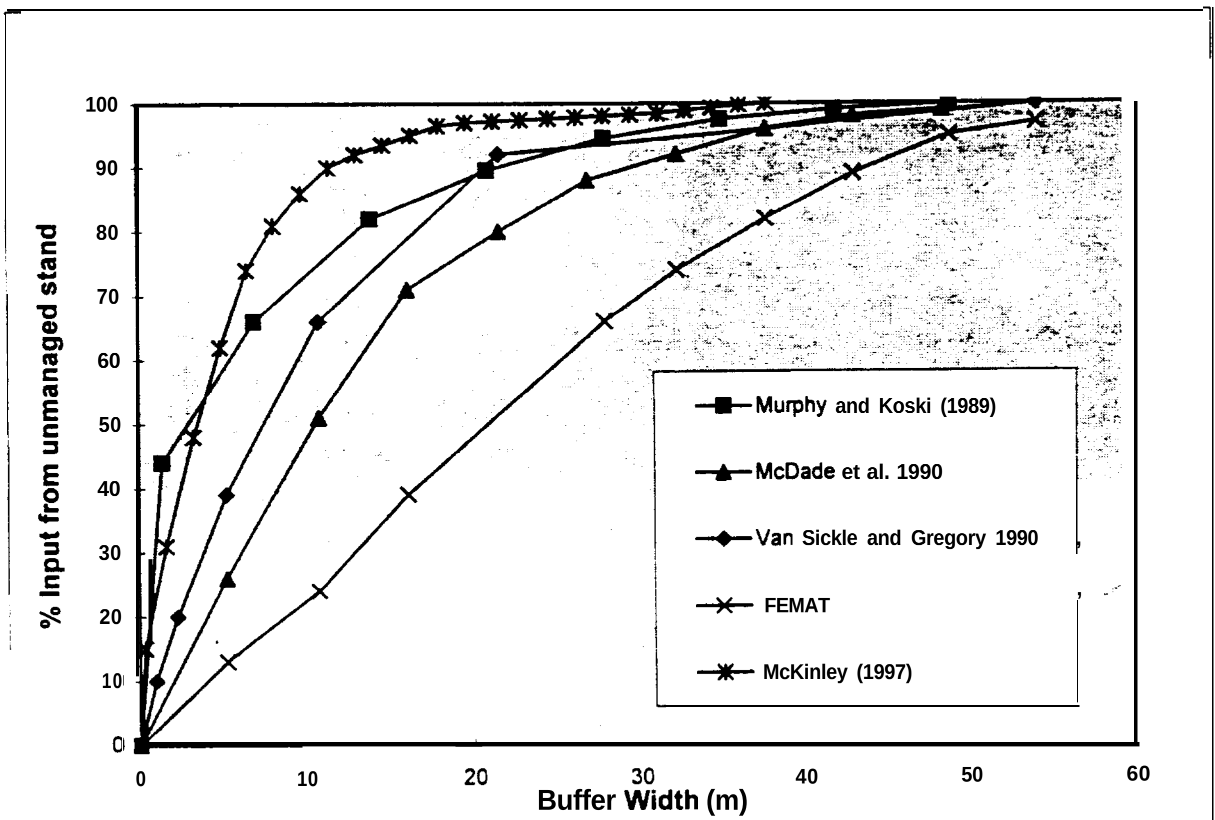
There is little doubt that large woody debris is important for the production of trout and salmon. Numerous studies have demonstrated the importance of LWD to anadromous fish (Bustard and Narver 1975a, 1975b; Bisson et al. 1982; Tschaplinski and Hartman 1983; Heifetz et al. 1986; Murphy et al. 1986; Holtby 1988; McMahon and Hartman 1989; Shirvell 1990). LWD benefits fish because it produces habitat characteristics important for fish survival and growth including scour pools, cover, and gravel deposits (Powell 1987; USDA 1993). In addition, LWD stabilizes stream channels, and can help retain leaves and other organic debris that provide inputs to the aquatic food chain (Powell 1987; Holtby 1988; Bilby and Bisson 1992).

The effects of riparian harvest and buffer strips on LWD recruitment are well known. In general, riparian harvest severely reduces recruitment of new LWD to streams and this effect persists for decades. Recruitment from regrowth, once it does occur, is smaller, more easily flushed by high flows, often decomposes quickly, and may require 100-200 years before it returns to levels present under pre-harvest conditions (Grette 1985; Murphy and Koski 1989). Retention of buffer strips reduces the magnitude of these effects because buffer strips provide sources for LWD recruitment. Within limits, wide buffer strips containing dense stands of coniferous trees are desirable for ensuring adequate LWD recruitment.

It is possible to quantify the effectiveness of buffer strips in providing for LWD recruitment. McDade et al. (1990) examined the source distances for LWD along 39 streams in western Oregon and Washington. Source distance measures the slope length from the stream bank to the rooting site for trees that have fallen into streams. Areas near the stream were important sources for LWD; 11 percent of all LWD pieces originated within 1 meter of the stream bank. By plotting the cumulative percentage of debris pieces versus source distance McDade et al. showed that 60-90 percent of all LWD originates from within 15 m of the stream bank (Figure 1). Areas within 30 m of the stream bank were the source for between 80 and 100 percent of all LWD. Murphy and Koski (1989) conducted a similar study along 32 stream reaches in Southeast Alaska. Their sites were located in undisturbed old growth forests, and were distributed between Rosgen type B and C channels [referred to as “riffle dominated” and “meandering,” respectively, in PL’s Watershed Analysis (R2 Resource Consultants 1996)]. Considering all study sites, Murphy and Koski found that over 40 percent of LWD originated from within a meter of the streambank (Figure 1, note this curve has been adjusted to account for the shorter site potential height of trees in their study site versus those on PL’s lands). Over 95 percent of LWD originated within 20 m of the stream. Results for type B and C channels differed slightly. B channels, which have higher gradient and confinement, were more likely to recruit LWD from greater stream distances. By contrast, almost half of all LWD in C type alluvial channels originated within 1 meter of the streambank. For both B and C type channels, over 94 percent of all LWD originated from within 20 m of the bank, and over 99 percent originated within 30 m of the bank (Murphy and Koski 1989).

Van Sickle and Gregory (1990) utilized data in McDade et al. (1990) to develop a LWD recruitment model. The model, which considers tree density and tree size distribution in riparian zones, was used to predict LWD inputs for a mixed height/species stand along the Siuslaw River in Oregon, and from a hypothetical 50 m tall stand of mature conifers. Their results indicated that a riparian buffer of 10 m provided over 60 percent of the volume of LWD expected in an uncut stand (Figure 1). The same 10 m buffer provided over 60 percent of the expected number of LWD pieces for the mixed height stand, but only 33 percent for a stand of uniform height. Similarly, a buffer 30 m in width generally provided over 90 percent of the LWD levels expected in uncut stands.

Figure 1 LWD Recruitment vs Buffer Width.



The exception is that the abundance of pieces in the uniform height stand was only 75-80 percent of levels in uncut forests. Van Sickle and Gregory's results demonstrate two general trends with respect to the design of buffers for LWD recruitment. First, the shorter the vegetation in the riparian corridor, the narrower the buffer can be without reducing LWD inputs. Second, because trees closer to the stream contribute longer LWD pieces of greater diameter, LWD volume declines quickly with source distance.

Robison and Beschta (1990) also constructed a recruitment model to evaluate LWD recruitment to streams. The model was designed for Douglas-fir, however it can be modified for any species if appropriate information on DBH/height relationships and tree taper are known. Their model recognizes that size and proximity to the stream bank both increase the likelihood that a given tree will contribute LWD to streams. Their model predicted that source distances for Douglas-fir increase with increasing diameter at breast height or DBH, largely because tree height and DBH are positively correlated. Robison and Beschta also provide a methodology to select individual trees that are likely to contribute LWD in the future. They suggest that this methodology could be used to identify trees available for harvest within riparian buffers.

McKinley (1997) evaluated large woody debris source distances for 17 stream reaches in the Cascade Mountains of Western Washington. Unlike the studies cited above, McKinley examined source distances in second growth stands (50-80 year old, predominantly conifer). His results are presented here to provide some guidance on what LWD recruitment from PL's second growth stands might look like. McKinley's results are similar to those already cited, that is, most LWD originates from areas near streams (Figure 1). However, for these second growth stands the amount of wood originating from near stream areas was even greater than for those in the old growth studies; he found that 50 percent of all LWD originated within 10 ft. of the channel and 95 percent originated from within 35 ft. In part, these results would be expected given the shorter tree heights in second growth of this age. His results suggest that over the 50 year period covered by this Plan streamside areas will be even more important for LWD recruitment into PL's streams, most of which have had riparian harvest, than would be expected given results from old growth forests.

The Forest Ecosystem Management Assessment Team (FEMAT) also examined LWD recruitment as a function of buffer width (USDA 1993). The FEMAT team did not conduct their own research, but rather reviewed scientific literature and data, primarily work conducted prior to 1993. The resulting LWD recruitment curve differs from that developed in the other studies reviewed here, even though FEMAT cites two of these studies as source data (McDade et al. 1990, Van Sickle and Gregory 1990). FEMAT's LWD curve is approximately linear, that is, all portions of a stream buffer are equal in terms of their importance as LWD source areas (Figure 1). This result appears to be in error. Buffer areas close to streams should be more important for LWD recruitment than other areas for a variety of reasons including:

- Trees that fall from areas near a stream are more likely to hit the channel than trees further away. For example, a 170 ft tall tree on the stream bank could fall anywhere within a 180° arc from directly upstream to directly downstream, and still end up in the channel. Conversely, a 170 ft. tall tree located 170 ft from the channel will only end up in the stream if it falls within a 1° arc, that is, straight toward the stream.

- A greater proportion of a tree located near the stream can end up in the stream compared to a tree farther away. Thus, using the example above, the entire length of the streamside tree could fall into the stream, whereas only the very top of the tree that is 170 ft away would enter the stream.

- The diameter and volume of trees decreases along the trunk from ground level to the tree top. Thus, trees nearer the stream are likely to contribute thicker, more voluminous pieces of LWD than are trees farther away. Again, using the above example, if the streamside tree fell directly across the stream the LWD it would contribute would be from the lower, thicker portion of the trunk. The tree that fell from 170 ft away, by contrast, would contribute only the tip of the tree.

- Streamside trees are especially likely to fall. This is true for two reasons. First, bank erosion by streams undercuts trees so that they are the most likely to fall. And two, many streamside trees grow out over the stream at an angle to better intercept sunlight. These leaning trees are more likely to fall than are trees that are not leaning.

The above studies indicate that buffer strips can retain most or all of the LWD recruitment potential that exists under old growth conditions. All the reviewed studies except FEMAT (USDA 1993) indicate that areas closest to the stream are the most important for LWD recruitment, but that the portion of buffers located 10-30 m or more away from the stream can contribute some wood. Accordingly, several authors have recommended that buffer strips should be equal to or greater than 30 m in width (Murphy and Koski 1989; Johnson and Ryba 1992; Davies and Nelson 1994; Ledwith 1996).

PL used the reviewed studies in an incremental benefit analysis to assess the LWD recruitment potential of its proposed Class I and Class II stream buffers as a percentage of the recruitment expected in unmanaged forests (Section 5). This analysis found that the 30 ft. “no cut” buffer along Class I streams, and 10 ft. “no cut” buffer along Class II streams combined with current forest practice rules would provide 75.2 percent and 34.6 percent of the LWD recruitment expected in unmanaged forests, respectively. The late seral portions of the Class I and Class II streams would provide an additional incremental LWD benefit of 4.6 percent, and 21 percent, respectively. Thus, as proposed, PL’s riparian buffers are expected to provide 79.8 and 55.6 percent of the total LWD recruitment expected in unmanaged forests in Class I and Class II streams, respectively. The estimate for Class I streams is somewhat low because the incremental benefit analysis assumed that the entire late seral buffer conformed to PL’s late seral retention standard. Instead, PL has proposed a middle buffer extending from 30-100 ft. that conforms to PL’s high residual area, late seral retention standard.

1.3.1.2. Organic Matter

The foundation of the aquatic food chain is built upon the various types of organic and inorganic nutrients that are stored in and/or pass through a stream system. Detritus (i.e., organic matter) is divided into three major classes based on size: coarse particulate organic matter [CPOM.(< 1 mm)]; fine particulate organic matter [FPOM(>0.45 Fm < 1 mm)]; and dissolved organic matter [DOM(<0.45 Fm)](Maltby 1992). Detrital matter can either enter the stream from terrestrial inputs (allochthonous) as leaf litter, needles, and twigs or be processed from within the stream (autochthonous) as algae or vascular plant material. Many low-ordered or headwater streams are primarily influenced from the canopy which shades the stream and reduces the amount of primary production (e.g., algae) at the same time contributing large quantities of allochthonous material in the form of CPOM (Vannote et al. 1980). As stream order increases, detrital material takes the form of FPOM that was processed in the headwaters and transported downstream, as well as autochthonous primary production (Vannote et al. 1980). The transition from headwater (orders 1-3) to middle-order streams (orders 4-6) also denotes the demarcation between heterotrophy (community respiration > primary production) and autotrophy (primary production > community respiration) (Vannote et al. 1980).

Coarse particulate organic matter generally enters the system as leaf litter, needles, twigs, and small woody material (Maltby 1992). Studies on leaf litter fall have dominated literature on the CPOM category of detritus. The composition of the riparian vegetation directly influences CPOM (Maltby 1992). Leaf litter fall is processed significantly faster than other types of CPOM (Webster and Benfield 1986), although conifer needles are processed much slower than leaf litter from deciduous trees (Barlocher and Oertli 1978). Processing or breakdown of CPOM depends on fiber content, nutrient levels, and inhibitory compounds (Maltby 1992).

Literature on the effects of riparian harvest and RMZ width upon CPOM is relatively scarce. Bilby and Bisson (1992) found that terrestrial inputs, dominated by leaves, were much greater at an old-growth site than at a clear-cut site. Terrestrial inputs were fairly high in old-growth streams throughout the year, while clear-cut streams received the majority of inputs through overhead vegetation over a short period of time. Richardson (1992) found that needle inputs were higher in an old-growth stream than in a second-growth stream in British Columbia, while the magnitude of leaf litter inputs were similar between the two.

FPOM can be the result of feeding by macroinvertebrates, physical abrasion, or flocculation of DOM (Maltby 1992). Literature on the effects of riparian harvest and RMZ width on fine particulate organic matter, like those for CPOM, are also limited. Bilby and Bisson (1992) found that algal production in streams bordered by both harvested areas and old growth stands was lowest in the winter in the Deschutes River, Oregon, while highest primary productivity levels were recorded in the summer (Bilby and Bisson 1992). The greatest difference between old-growth and clear-cut streams was seen when primary production peaked during the summer months; total autochthonous production in the clearcut site increased above levels in the old-growth site, leading to higher coho salmon production in the harvested area.

Several studies have examined invertebrate communities in streams with RMZ buffers. These studies can provide insight into the width and silvicultural prescriptions necessary if buffers are to provide for normal levels of organic matter input. This is so because invertebrates are sensitive to both the types and quantities of organic matter delivered to streams (Merrit and Cummins 1984). For example, a functional feeding group of stream invertebrates referred to as "shredders" typically depends upon decomposing CPOM such as leaf litter as food. Changes in either the abundance or quality of CPOM, then, should be detectable by documenting changes in shredder abundance and diversity. Similarly, "collector-filter feeders" and "scrapers" depend upon FPOM and attached algae (i.e., periphyton), respectively, for food. Even invertebrate studies that only quantify total invertebrate abundance as a function of buffer width or silviculture are valuable because although fish may preferentially use some invertebrate types, fish production is also related to total invertebrate availability (Bilby and Bisson 1992).

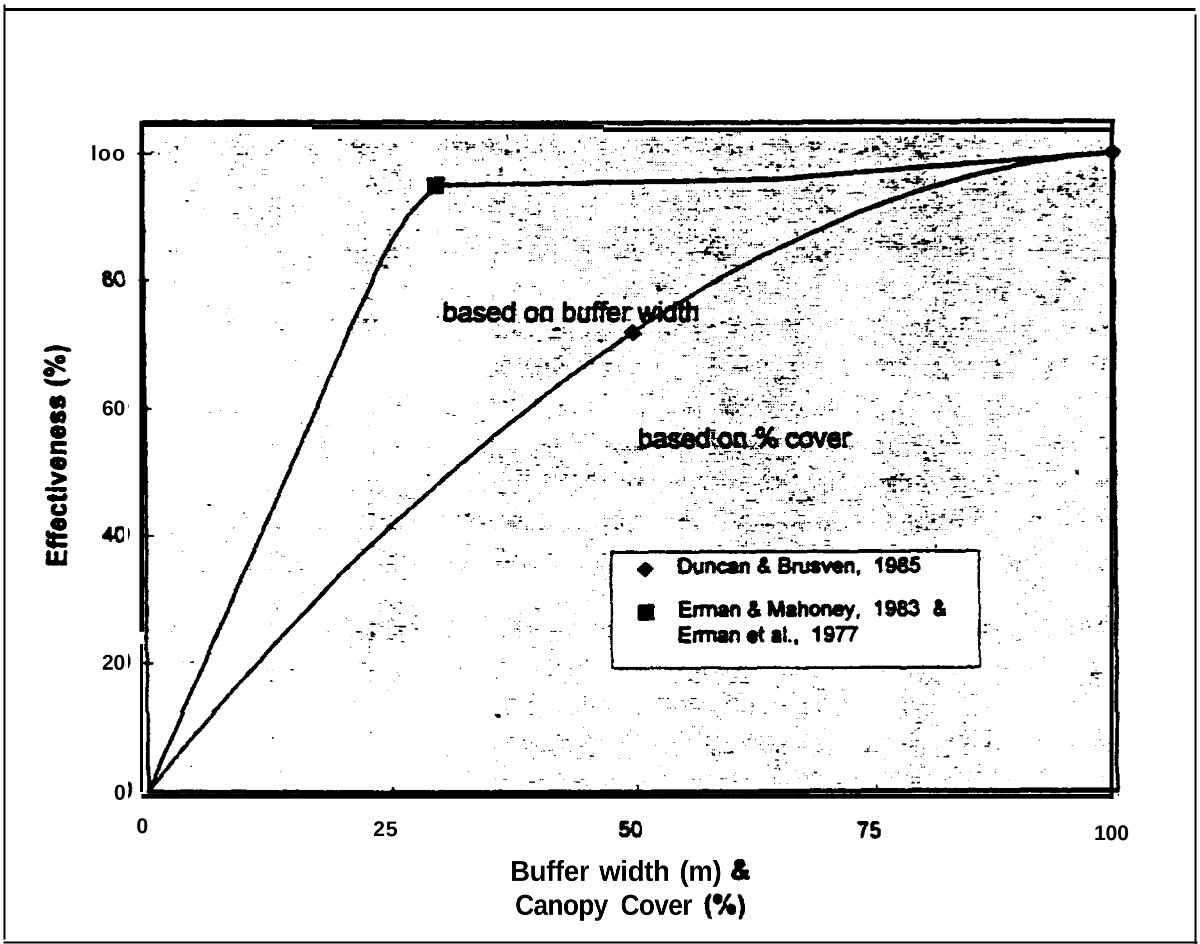
Result of a draft NCASI technical report (Castelle and Johnson, 1998) showed that 30 m buffer strips were nearly 100% effective in maintaining pre-harvest invertebrate communities (Figure 2). Furthermore, in comparisons of pre-harvest and post-harvest macroinvertebrate diversity, sites with 30 m buffers showed no significant change in macroinvertebrate diversity (Figure 2). A similar result was also noted by Erman et al. (1977) who observed that streams with buffers of 100 ft or greater had benthic macroinvertebrate communities that were indistinguishable from those in streams flowing through unmanaged forests. The authors of FEMAT (USDA 1993) used results from Erman et al. (1977) and professional judgement to conclude that organic matter inputs from 100 ft buffers were sufficient to maintain biotic community structure.

Although literature to evaluate the effects of buffer width and management on organic matter inputs is limited, the studies reviewed by PL clearly indicate that riparian areas subjected to significant harvest (e.g., clearcutting) experience changes in both the abundance and type of organic matter inputs. However, this review also indicates that riparian buffers of 100 ft. or greater are likely to maintain the invertebrate communities that utilize organic matter, and, in turn, the fish communities that depend upon the invertebrates for food. Consequently, it appears that the 170 ft and 100 ft buffers proposed by PL for Class I and Class II streams, respectively, will fully provide for organic matter inputs that will support aquatic resources on the ownership. This conclusion is likely conservative because it ignores numerous studies that have documented increased invertebrate and or fisheries production in streams following partial or complete riparian harvest (see section 1.3.1, Background).

1.3.1.3. Water Temperature and Streamside Canopy Levels

Natural thermal characteristics in streams are determined by many factors including latitude, altitude, season, time of day, flow, and channel width and depth. In addition, the amount of stream shading present, from topography or vegetation, is important in determining water temperature conditions. When riparian shading conditions are reduced streams are subjected to increased inputs of solar energy (Bilby and Bisson 1992; Murphy et al. 1992). Reduced tree cover over the water surface also reduces a stream's thermal insulation. Both factors can result in an increase in water temperature. Conversely, more open canopies may enhance evaporation rates, and therefore evaporative cooling.

Figure 2 Effectiveness of Vegetation: Protection of Invertebrates



Management activities such as tree thinning and clear cutting can reduce shading and thermal insulation within the riparian corridor and can alter the natural thermal conditions within a stream (Bilby and Bisson 1992; Murphy et al. 1992; Holtby 1987). In general, management activities result in increased thermal loading, particularly during the summer months when solar radiation is at its highest, which, as noted above, can result in elevated stream temperatures. In addition, increases in thermal loading are generally cumulative such that downstream portions of streams are often warmer than upstream locations. Conversely, during the winter, riparian canopy removal can result in additional heat loss and a subsequent decrease in winter water temperature minimums (Beschta et al. 1987), although other studies have observed the opposite effect (Holtby 1988). In general, the magnitude of management effects on stream thermal characteristics is determined by the size, type, and age of the forest canopy cover before and after management activities, and on the size of the channel (width and depth). Geographic location can also affect the impact of management activities on temperature. Within cool coastal climates temperature increases related to harvest are not as likely to produce stressful or lethal conditions as are increases in warmer climates that may already produce naturally high stream temperatures.

Numerous studies have examined the impacts of timber management in RMZs on water temperature. Perhaps the most applicable was a study by Burns (1972). He examined the effect of logging on water temperatures within streams in Northern California, including a site on PL's ownership (South Fork of Yager Creek). Burns (1972) found that water temperatures were higher in streams segments containing clear cut areas than in similar stream segments containing uncut buffers bordering the stream. At one site, he determined that water temperatures increased approximately 1.0°C per 100 m of stream running through clearcut areas. Temperatures decreased 0.5°C per 100 m of intact riparian vegetation. This result was generally applicable to all study sites. However, within the South Fork of Yager Creek, water temperatures were consistently high both before and after logging with a typical summer maxima of 21.5°C (Burns 1972). Burns (1972) attributed the lack of increase in water temperatures in South Fork Yager following harvest to the buffer of riparian vegetation left along the stream which provided thermal insulation and prevented water temperatures from reaching lethal levels. Burns' observations demonstrated the effectiveness of buffers in controlling temperature in Northern California coastal streams. He also documented that high water temperatures were present in the Yager Creek basin even under old-growth conditions, which supports observations by PL's foresters that stream temperatures in portions of the ownership isolated from cool ocean breezes are often high regardless of harvest history.

Doughty et al. (1993) reviewed maximum daily summertime temperature values from approximately 20 forested stream reaches in Washington State with mature forest canopy and found a generally increasing trend as the site distance from the watershed divide increased. They attributed this phenomena to four primary factors: (1) as drainage area increases there is generally a corresponding increase in average stream width which reduces the effectiveness of riparian vegetation in providing shade to the stream surface; (2) as flow volume increases the ability of groundwater inflow to reduce stream water temperature decreases; (3) as with stream width there is generally a corresponding increase in stream depth as distance from the divide increases, and; (4) air temperature generally increases at lower, valley bottom elevations.

Doughty et al. reported that daily maximum temperatures for stream reaches located approximately 12 miles from a watershed divide are likely to exceed 16.3°C and that temperatures for sites located greater than 30-40 miles from a divide are likely to exceed 18.3°C regardless of upstream forest management activities.

Barton et al. (1985) examined the riparian buffer strip dimensions required to maintain trout habitat in Souther Ontario, Canada. They observed weekly maximum temperatures in 38 streams with from 0 -100 percent riparian tree cover. Using field measurements, they found that both buffer strip width and length were important factors in determining RMZ effectiveness in controlling stream temperatures after logging; maximum temperatures were reduced as the length and width of forested buffers increased. For example, measurements along the length of streams demonstrated that water temperatures decreased approximately 0.5°C every 32 m as they entered stream reaches containing buffer strips within their study. Barton et al. (1985) suggest that their work in estimating buffer width effectiveness should be applicable to most areas with similar climates. The work is important because it incorporates a concept, buffer continuity, that has generally been ignored in previous studies. Their results indicate that the continuous nature of the riparian buffers PL is proposing will have a positive cumulative impact that results in lower stream temperatures than would be expected based on studies that examined the effects of harvested and unharvested “patches” of riparian vegetation.

Belt et al. (1992) examined the effects of buffer strips on reducing thermal impacts of forest practices. Many of their reviewed studies found minimal management effects on temperature, a result attributed to retention of buffer strips and/or fast regrowth following harvest. In general the studies they reviewed indicated that removal of forest canopy within the buffer strip reduces its effectiveness by reducing shade, thereby, increasing stream temperatures. Belt et al. (1992) also recommended the use of computer models to design more effective buffer strips to control temperatures.

The Washington Forest Practices Board (WAFPB 1992, 1994) evaluated RMZs to determine buffer strip widths and leave tree requirements that would provide adequate shading to maintain suitable water temperatures for aquatic organisms. Of the reaches studied in Western Washington, RMZ widths ranged from as narrow as 1.5 m to as wide as 57.9 m. Differences in buffer width effectiveness in controlling temperature were associated with variability in stream channel width, elevation, and average riparian shade before harvest. Although site specific analyses were encouraged, the WAFPB (1994) also developed minimal leave tree rules for streams that were identified as having the potential for adverse, post-harvest impacts on water temperature. These rules state that all nonmerchantable vegetation providing mid-summer and mid-day shade of the water surface must be retained within the RMZ. In addition, sufficient timber must be left to retain 50% of the summer mid-day shade of the water surface and 75% of the shade in streams where the mean of the maximum summer day water temperatures exceed 15.55°C during a seven-day period (TAW 1992). Based on these and other studies the WAFPB has concluded that: (1) by the time a stream has traveled 1,000 ft or more under relatively uniform canopy cover, water temperature will be in equilibrium with local environmental conditions, and (2) streamside shade is unlikely to have a significant influence on stream temperature where the natural low flow channel width exceeds 100 ft (WAFPB 1995).

Adam and Sullivan (1990) make several conclusions regarding the relationship of stream temperature to significant environmental parameters: (1) stream depth is the most important geometric parameter affecting both the magnitude of stream temperature fluctuations and the response time of the stream to changes in environmental conditions; (2) daily mean stream temperature is generally within a couple of degrees from daily mean air temp and is strongly influenced by fluctuations in air temperature; (3) reduction in streamside shade levels has a relatively modest impact on mean stream temperature, but has a much stronger affect on diurnal fluctuations in stream temperature; (4) groundwater inflow can have a significant depressing effect on stream temperature depending on rate of inflow and difference in groundwater temperature and mean stream temperature.

The effectiveness of vegetation buffer strips in controlling water temperatures has been examined in at least three other studies. Osborne and Kovacic (1993) reviewed several studies on temperature control using RMZs. They found that buffer widths needed for effective temperature control ranged from 31 m for a study in Pennsylvania to 10 m within an Oregon mountain stream. A review of several studies conducted by Johnson and Ryba (1992) determined that RMZ efficiency in controlling water temperature increased with increasing buffer width. Most of the studies they reviewed recommended buffer widths of 30 m or less to maintain water temperatures (Table 5). Finally, FEMAT (USDA 1993) concluded that despite canopy density and buffer width variability, a 30 meter wide buffer typically provided as much thermal shading as that from an old-growth forest.

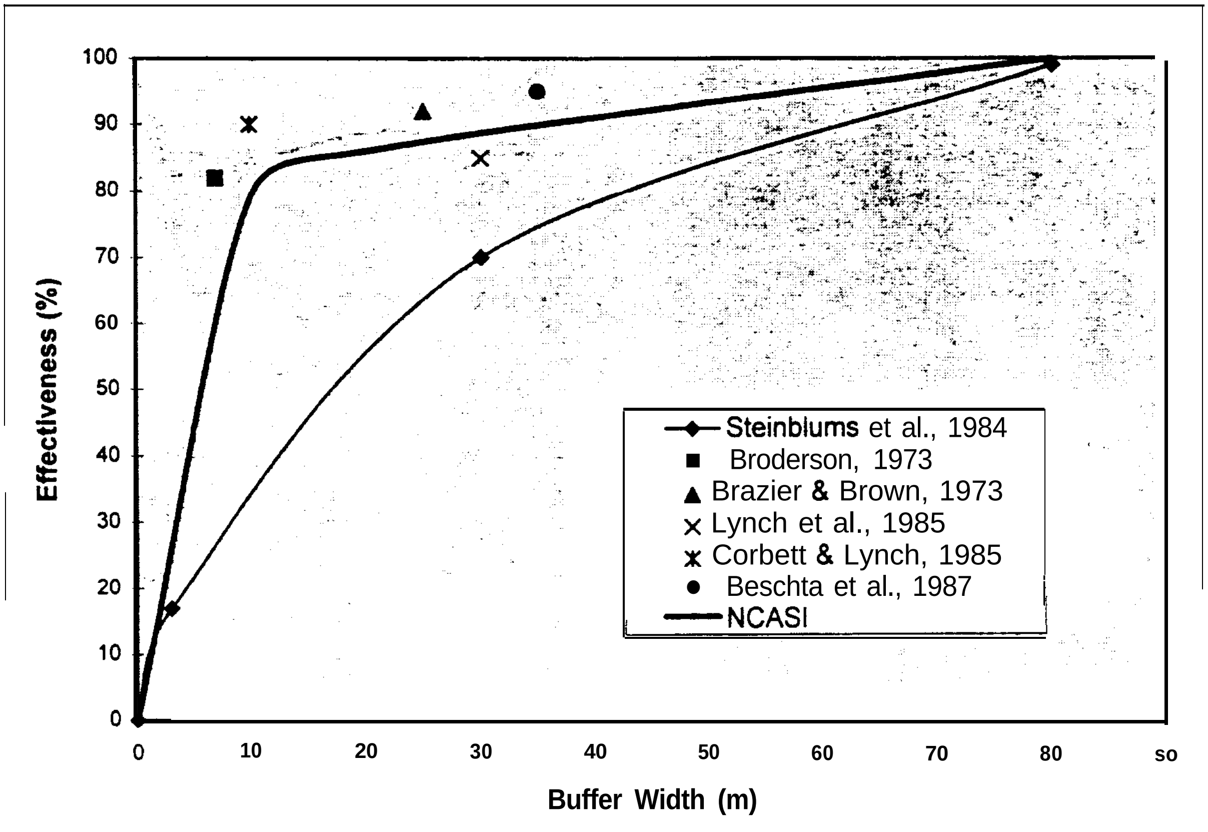
The width of the buffer strip is an important component in maintaining relative humidity within riparian areas. Ledwith (1996) found that when buffer widths are insufficient to control solar radiation, air temperatures can increase within the stream corridor resulting in decreased relative humidity. These changes can have several impacts on the riparian ecosystem including increased water temperatures. He determined that buffer strips of 30 m or wider can significantly reduce air temperature changes within the riparian corridor. Buffers 30 m wide provided approximately 55-70 percent of the total air temperature reduction observed in buffers 150 m wide.

Although buffer strip width is an important variable in maintaining stream temperatures, the volume of timber within a buffer strip is not well correlated with shade (Braizer and Brown 1973). Rather, it is the canopy actually shading the stream, known as the angular canopy density (ACD), that has been shown to provide the best measure of the cover necessary to maintain stream water temperatures (Braizer and Brown 1973). ACD integrates several factors such as stream width, tree height, and canopy density which are factors important in buffering thermal inputs. Braizer and Brown (1973) measured the ACD, and found that the maximum ACD occurred with the use of a 25 meter buffer strip, and 90% of the maximum ACD was obtained with an 17 meter buffer strip (Figure 3). Steinblums et al. (1984) similarly determined that an ACD of approximately 70 percent could be achieved with the use of a 31 meter buffer strip (Figure 3). Given their demonstrated effectiveness, RMZs are widely used to reduce or prevent the impacts of timber harvest on stream temperatures. The primary factors influencing the effectiveness of RMZs to prevent temperature increases are site elevation, air temperatures, groundwater flux, stream morphology, and post-harvest shade levels, (TAW 1992):

Table 5. Summary of literature derived impacts of timber management in RMZ's on water temperature.

Author (year)	Location	Conclusions
Burns (1972)	Northern California, including PL ownership	Water temp. increased 1.0^{o}C/meter of clear-cut, and decreased 0.5^{o}C/meter of uncut stream bank.
Doughty et al. (1991)	Washington State	Generally increasing temperatures with increasing site distance from the watershed divide.
Barton et al. (1985)	Ontario, Canada	Stream temperatures decreased 0.5^{o}C for every 32 m of buffer strip.
Belt et al. (1992)	Literature review	Removal of forest canopy within the buffer strip reduces its effectiveness by reducing shade, thereby, increasing stream temperatures.
Washington Forest Practices Board (1992, 1994)	Western Washington	1) By the time a stream has traveled 1000 feet or more under relatively uniform canopy cover, water temperature will be in equilibrium with local environmental conditions. 2) Streamside shade is unlikely to have a significant influence on stream temperature where the natural low flow channel width exceeds 100 feet.
Adam and Sullivan (1989)	Published conclusions	Reduction in streamside shade levels has a relatively modest impact on mean stream temperature.
Osborne and Kovacic (1993)	Literature review	Buffer widths needed to control stream temperature ranged from 31 m to 10 m.
Johnson and Ryba (1992)	Literature review	Most studies reviewed recommended buffer widths of 30 m or less to maintain water temperatures.
FEMAT (USDA 1993)	Literature review	30 meter wide buffer typically provided as much thermal shading as that from an old-growth forest.

Figure 3 Effectiveness of vegetation: Shade production.



- Temperatures within streams located at higher elevations (e.g., >600 m in Washington State) are likely to be affected primarily by air temperatures and seasonal fluctuations, rather than harvesting activities (WAFPB 1994).
- Streams located in areas with high air temperatures will tend to have higher water temperatures than streams in areas with low air temperatures. This was noted above in the results for Burns (1972) study of South Fork Yager Creek.
- Forested streams with substantial inputs of groundwater are generally cooler and less responsive to heat inputs than streams with low groundwater inputs.
- Streams with a channel morphology dominated by shallow depths, and long residence times for water are more likely to experience high water temperatures because of the increased opportunity for thermal loading.
- Streams with high shade levels (>95%) have greater thermal insulation from solar radiation, and are therefore likely to experience lower water temperatures than similar streams with low shade levels.

Of these factors, shade, and in some cases, channel morphology, are the only variables that can be managed to reduce the adverse affects of timber harvest on water temperature within forested streams. Shade levels can be managed directly by controlling the amount of vegetation removed from RMZs. And in those streams that have become shallower and wider in response to management related sediment inputs, control of such sediment can restore channel morphology to a condition that reduces thermal loading.

Identifying an "ideal" RMZ width for temperature control is difficult because of the large number of site specific variables that determine a buffer's effectiveness at controlling stream temperatures as discussed above. However, virtually all of the studies reviewed here indicated that vegetated RMZs varying from 33-140 ft in width are effective at controlling stream temperatures. The most common result indicated that an RMZ of 100 ft. or greater is effective at controlling stream temperatures (Table 5, Figure 3). Given this, the 170 ft. and 100 ft riparian buffers proposed by PL for Class I and Class II streams, respectively, are clearly wide enough to fully provide for protection of water temperatures in streams on the ownership. The only question regarding effectiveness is whether the limited harvest PL will conduct in its RMZs will produce the expected temperature benefit of these buffers. Three types of evidence indicate that harvest will not significantly reduce RMZ effectiveness for temperature:

- Harvest within RMZs is severely restricted under this Plan. Both Class I and Class II streams contain "no-cut" zones adjacent to streams where vegetation density will not be affected by harvest. Restrictions on harvest within late seral buffers include single tree harvest only, minimum stand densities and size distributions before and after timber harvest, a maximum of one harvest every 20 years, and a limit on the total volume of wood that can be removed in any one entry. Importantly, these restrictions on harvest in late seral zones are so severe that harvest in many of them will not even be “allowed” for decades.

- A recent study examined the canopy levels of riparian areas that have been harvested under existing Forest Practice Rules in California. This study documented that post-harvest canopy levels under current rules exceed 70 percent. Given all the additional restrictions on riparian harvest PL is proposing as part of its Plan, canopy levels will certainly increase above those resulting from existing rules. When combined with studies showing that canopy in unmanaged forests averages 75-90 percent (Erman et al. 1977) it is clear that PL’s prescriptions have a high probability of achieving or nearly achieving canopy levels found in unmanaged systems.

- As with LWD, PL used an incremental benefit analysis to assess the canopy closure expected if its RMZ prescriptions are implemented. These canopy closure levels were expressed as a percentage of the canopy closure expected in unmanaged forests (Section 5). This analysis found that the 30 ft. “no cut” buffer along Class I streams, and 10 ft. “no cut” buffer along Class II streams would, in concert with forest practice rules, provide 79.2 percent and 59.6 percent of the canopy closure expected in unmanaged forests, respectively. The late seral portions of the Class I and Class II streams would provide an additional incremental canopy benefit of 14.6 percent, and 15.9 percent, respectively. Thus, as proposed, PL’s riparian buffers are expected to provide 93.6 and 75.5 percent of the total canopy cover expected in unmanaged forests in Class I and Class II streams, respectively.

Overall then, it seems very likely that PL’s HCP measures will fully protect conditions necessary for suitable water temperatures in streams on the ownership.

1.3.1.4. Channel Stability

Channel formation/stability is an important function of riparian ecosystems. As discussed in previous sections, destabilized channels are subject to numerous changes including bank erosion, channel widening, channel straightening, instream sedimentation, and removal of LWD deposits (Culp 1987; Harris 1988; Powell 1987; WAFPB 1994). These changes can negatively affect invertebrate and fish abundance and production through reductions in important habitat elements such as overall complexity, pool size and frequency, and sediment particle size (Culp 1988; Holtby 1988; WAFPB 1994). Although channels are inherently dynamic, timber management activities can significantly increase the rates and alter the types of change present under natural conditions (USDA 1993; WAFPB 1994; WADNR 1996).

Any discussion of channel stability must consider the intrinsic stability of different channel types. Channel types fall into two broad categories: unconfined alluvial channels that are controlled by the balance between flow and the sediments that compose the valley floor; and constrained channels which are primarily controlled by external structures such as bedrock (Chamberlain et al. 1991; Montgomery and Buffington 1993). Within each type various subclasses can be identified based on substrate size and gradient (WAFPB 1994). In general, confinement and larger substrates (e.g., boulders or bedrock) confer a natural stability to channels. Conversely, unconfined channels with fine grained sediments tend to be less stable, often showing marked changes in morphology in response to changes in flows, sediment supply, and LWD levels (Chamberlain et al. 1991). Unconfined channels of all types tend to “migrate” over time across floodplains.

LWD and the roots of trees and other vegetation serve as secondary controls in both of the general channel types outlined (Bisson et al. 1987; Sullivan et al. 1987; Chamberlain et al. 1991; WAFPB 1994). Although constrained channels are often laterally stable, LWD can significantly alter bed morphology by acting as small dams. Sediment is trapped upstream of these LWD dams, whereas plunge pools often form immediately downstream (Bisson et al. 1987; Potts and Anderson 1990). The net effect is to produce a “stepped” longitudinal profile that contains significantly more habitat diversity for fish. In addition, the increase in energy dissipating structures, and the structural complexity of the stepped profile favor the retention of organic matter that would otherwise flush quickly through constrained channels. This retention is probably important to the aquatic food chain of these channels (Bisson et al. 1987). In unconstrained channels LWD can help “armor” stream banks, or act as sediment catching dams within the active channel. However, LWD can also have the opposite effect by creating localized scour of both the bank and streambed. This scour, although technically increasing instability, is desirable because it often produces habitat elements important to fish.

The stability of both channel types is also sensitive to the balance between sediment transport during floods and sediment delivery (Sullivan et al. 1987; Chamberlain et al. 1991; WAFPB 1994). When sediment delivery exceeds sediment transport constrained channels aggrade, with subsequent filling of deep water habitats, and the burying of LWD and other roughness features within the channel. Under similar circumstances unconstrained channels also aggrade, but the result differs in that the aggradation also causes a widening and straightening of the channel, with resulting increases in bank erosion and channel migration (Powell 1987). When sediment transport exceeds delivery, the result is channel scouring. Although timber management usually results in an increase in sediment delivery rates, management actions can decrease LWD levels or increase peak flows (Harr et al. 1975). Both changes can increase sediment transport. Thus timber harvest can result in an increase in both sediment delivery, and channel scour and thus may have little net effect on sediment levels in streams.

Riparian trees and plants enhance channel stability because their roots increase bank cohesion, and the aboveground portions dissipate energy during overbank floods (Johnson and Ryba 1992). This is especially important in unconstrained channels where channel stability is strongly related to scour force and bank cohesion. Riparian vegetation is also important in the restabilization of stream channels. Increased vegetation along streams can strengthen stream banks leading to a narrowing and deepening of stream channels.

The above discussion indicates that an analysis of the effects of RMZs on channel stability must be tailored to channel type. For constrained channels LWD and sediment transport/deposition are important in determining channel stability. LWD is the more important of the two because it both stabilizes channels directly, and affects sediment transport/deposition. LWD is also the influence most affected by RMZs since much of the sediment inputs related to logging originate from sources outside of the riparian zone (e.g., Hartman et al. 1996). For unconstrained channels LWD delivery is also important, but root strength and the density and type of vegetation present in the riparian corridor need to be considered as well.

The effects of RMZs on LWD recruitment were discussed above. This review indicated that PL's proposed HCP measures for RMZs can provide for LWD recruitment levels comparable to those in unharvested systems. By extension, therefore, these measures can provide the LWD elements needed for channel stability in both constrained and unconstrained channels on PL's lands.

The effectiveness of RMZs in protecting roots that help banks resist erosion is more poorly known. Culp (1988) reported on the stability of two stream reaches on Carnation Creek, British Columbia. One reach (Site 630) contained an RMZ that retained only non-merchantable trees, but was otherwise harvested to the stream's edge. Harvesting within Site 630 also excluded felling and yarding across the stream. The second reach (Site 1480) was completely clearcut, cross channel yarding was allowed, and instream LWD was removed. Following harvest the banks and instream LWD within Site 630 remained stable. By contrast, Site 1480 experienced bank erosion and bed scour, with the result that the section became channelized with subsequent losses in invertebrate and fish production. Culp's work suggests that even partial retention of riparian vegetation, and careful avoidance of bank disturbance during harvesting, are sufficient to prevent channel instability.

Powell (1987) tracked bank and instream LWD stability in another portion of the Carnation Creek basin. He found that retention of an RMZ of variable width was sufficient to retain bank stability and instream LWD deposits for over 15 years. This stability persisted despite the downstream transport of sediments and LWD from upstream areas that destabilized following logging. When a small section of the buffer was logged, the otherwise stable channel widened into the harvested area. This suggests that a relatively undisturbed RMZ was required to retain channel stability. When Powell examined the effects of "careful" and "intensive" streamside harvest he found that both treatments resulted in bank erosion and channel instability. Apparently the avoidance of cross channel felling and yarding, the removal of logging slash from streamside areas, and the retention of non-woody bank vegetation (the careful treatment) were not sufficient to maintain channel stability.

Hartman et al. (1996) reported on changes in the stability of the Carnation Creek system for the 8 years subsequent to the work cited above by Culp (1988) and Powell (1987). They confirmed that stream reaches clearcut to the bank destabilized with subsequent losses of instream LWD, and increases in bank erosion and channel width. Despite 12 years of riparian regrowth in some sections bank stability had not increased. They anticipate that recovery will require decades as increasing vegetative growth and flushing of excess sediments slowly restore channel stability. Future LWD recruitment was identified as being crucial for this recovery. Hartman et al. recognized that effective buffer widths vary depending on channel type (i.e., constrained versus alluvial), and that buffers equivalent to 10-14 channel widths in size might be required for the most disturbed alluvial channels.

FEMAT (USDA 1993) indicated that root strength increases rapidly with the width of a retained riparian buffer. Based on personal communications and two studies not listed in the bibliography of their report (Burroughs and Thomas 1977, Wu 1986), FEMAT concluded that "the contribution of root strength to maintaining streambank integrity...declines at distances greater than one-half a [tree] crown diameter." A generalized curve in the same document indicates that streambank stability is maximized when the riparian buffer is 0.3-0.5 the site-potential tree height in width (50-85 ft on PL's lands).

An unpublished technical report by NCASI (Castelle and Johnson, 1998) evaluated the effectiveness of streamside vegetation in promoting channel stability. They report that the ability of riparian plant roots to bind streambank soils increases resistance to erosional forces and the increased bank stability provided by deep root anchoring may help to maintain low width-to-depth ratios and allow for streambank undercutting and reduced streambank erosion. Further streambank stabilization may be provided by a reduction in soil moisture (soil pore water pressure) by root uptake and subsequent transpiration that may otherwise result in bank instability. The extent to which tree roots influence streambank stability is determined by the distance the root system extends from the tree. The authors concluded that for the majority of tree species, the root system extends radially from the tree for a distance that approximates the outer edge of the tree crown.

Collectively the above studies indicate that clearcutting to the edge of streams can result in significant channel instability, despite attempts to reduce disturbance to the banks. However, it is not clear how much of the riparian vegetation is needed to maintain stability. One set of authors indicated that most of the active floodplain could be required (Hartman et al. 1996), whereas another found that retention of non-merchantable timber alone could prevent destabilization (Culp 1988). With respect to the Northern California coast, a confounding factor is that redwood trees, the dominant conifer along many streams, resprout following harvest. Hence, decreases in root strength following harvest, and the interval until regrowth could provide new sources of LWD, are probably much lower that in the reviewed studies.

Although the reviewed studies prevent making any definitive conclusions, PL's HCP measures for RMZs are expected to provide conditions conducive to maintaining bank stability. This conclusion is based on:

- PL's proposed retention of 30 ft. and 10 ft. "no-cut" buffers on Class I and Class II streams, respectively. Trees in the critical streambank areas will, therefore, not be subjected to disturbance and are likely to result in high root densities. This is especially true for Class I streams where the 30 ft. "no-cut" buffer is greater than half the crown diameter, and therefore, based on FEMAT (USDA 1993) and Castelle and Johnson (1998) is likely to lead to root strengths equivalent to those in unmanaged forests.

- PL's late seral buffers have numerous restrictions on harvest, as noted above in the discussion for temperature, that will lead to high densities of large trees. Thus, the late seral buffers are expected to contribute significantly to root density and strength in the RMZs.
- As noted in the section on LWD, PL's proposed RMZs are expected to result in high levels of LWD recruitment to streams. Thus, to the extent that LWD contributes to the stability of individual channels or channel types, PL's mitigation measures will provide for fully functioning conditions.
- Much channel instability is related to excessive sediment loading. Because PL's proposed HCP measures are expected to significantly reduce sediment loading to streams (see below) PL will minimize this potential source of channel instability.

1.3.1.5. Sediment Input-Surface Erosion

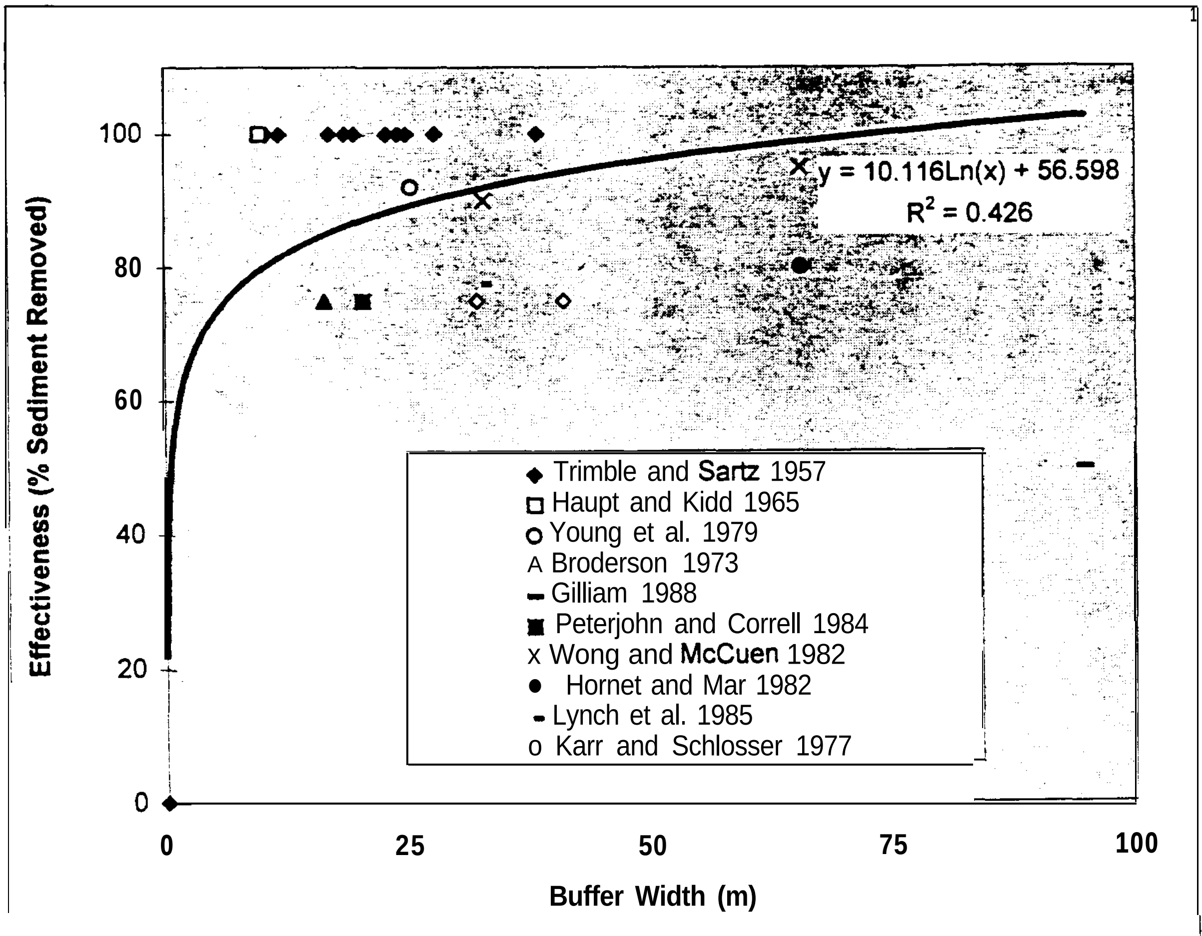
Sediment conditions within streams and rivers are of interest for two reasons. First, management activities within watersheds can significantly increase sediment delivery to streams compared to natural levels (Chamberlain et al. 1991; Powell 1987; WAFPB 1994, Weaver and Hagans 1994). Second, sediments, whether from management activities or natural sources, can have important impacts on aquatic biota, particularly fish (Bjornn et al. 1977; Chapman 1988; Steele and Stacy 1994).

Timber harvest can increase sediment inputs to streams via erosion from roads, landings, and harvest areas, during construction activities, by increasing soil moisture in forests, by reducing root density and thus soil cohesion, and by causing bank erosion (Burns 1970; 1972; Chamberlain et al. 1991). Management related sediment enters streams primarily through one of two processes, surface erosion from roads and disturbed areas, and mass wasting (WADNR 1994). [Note-sediment inputs from mass wasting are discussed in the next section.] Surface erosion involves the displacement and transport of smaller soil particles (e.g., clays and silts) from road use, precipitation, and dry ravel. The smaller clay and silt particles related to surface erosion from roads and disturbed areas are of concern because they are easily entrained in surface runoff and transported directly to streams where they can negatively impact aquatic biota (Moring 1987, Lloyd et al. 1987; Bjornn et al. 1977; Platts et al. 1983).

Numerous studies have demonstrated that vegetated buffers reduce sediment delivery to streams. For example, Erman and Mahoney (1983) conducted a review of studies on recovery following logging in buffered and non-buffered streams in northern California. They found that sedimentation control increased in streams with buffer strips wider than 20 m. However, sedimentation was not sufficiently controlled in streams with buffers of less than 5 m (Figure 4).

Burns (1970) examined the sedimentation of spawning beds before and after logging in six coastal streams in Northern California, including the South Fork of Yager Creek (located within PL's ownership). Logging was conducted between 1967 and 1969 within the test sites using site-specific methods. Monitoring of sediment composition in test and control sites was conducted

Figure 4 Buffer effectiveness in removing sediment from runoff.



for three years to determine the effects of harvest activities on salmon and trout habitat. Prior to logging the mean percentage of particles < 0.8 mm was 16.4 in the South Fork of Yager Creek test area. Twelve months after logging, the mean percentage of particles < 0.8 mm within the South Fork Yager Creek test area was 23.6. A 7.2 percent increase in fine sediment was observed within 1 year after harvest. However, other watershed disturbances may have confounded Burns' results; he reported that fine sediment increased by 5.7 percent within the control section of the South Fork Yager Creek during the study period. Thus the absolute difference in fine sediments between the logged and unlogged stream sections was 1.5 percent.

Although Burns (1970) demonstrated that clearcut logging along streams could increase sediment levels, he also found that mitigation measures could prevent most of these sediment impacts. For example, the proximity of roads to streams was an important factor in streambed sedimentation; roads constructed greater than 30 m from the stream channel on low gradient slopes did not contribute to the sedimentation of spawning beds. Similarly, he reported that wide buffers on low gradient slopes provided a filter or absorbed turbid runoff before it was discharged into streams. Burns noted that quickly completing harvest activities, limiting repeated disturbance, and avoiding additional road construction can increase the recovery of spawning beds following logging. This was particularly true for fine sediments which were flushed out of streams once the sources of erosion were removed.

Johnson and Ryba (1992) reviewed studies examining the ability of vegetated buffers to trap sediment. They determined that the effectiveness of a buffer is dependent on a number of factors including particle size, slope, roughness of vegetative cover, and runoff characteristics. These factors affect the ability of vegetation to remove sediment from the water column by slowing surface water flow and causing sediments to settle. In general they concluded that 90 percent of all sediment was removed by a 100 m wide buffer if slopes were low. However, they found that buffer width and sediment removal are non-linear and that even small incremental increases in sediment removal required disproportionately wider buffers. For example, a 5 percent increase in sediment removal from 90 to 95 percent would require a two- fold increase in buffer width; in this case from 100 m to 200 m given a 2 percent slope. A study conducted by Lynch et al. (1985) focused on controlling non-point source pollution (including sediment) on forested watersheds. The study was conducted in a Pennsylvania forest following a clearcut. The impact of the clear cut was compared with an adjacent clearcut, a herbicide treated watershed and a forested control. In general, the study determined that buffer strips of 30 m or more were sufficient to control sedimentation resulting from forest practices (Figure 4).

An important variable in determining the effectiveness of RMZs of reducing sediment delivery to streams is percent slope. In general the steeper the slope, the wider the buffer strip required (Belt et al. 1992; USDA 1993). For example, Belt et al. (1992) found that to trap approximately 90 percent of non-channelized sediment flow, buffer strips of 7.6 m were needed for areas with negligible slopes, while buffer strips of 52 m were needed for areas with 70 percent slopes. They report that sediment discharged from other sources including fill slopes, berm drains, and rock drains can be adequately controlled by buffer strips.

Several studies focusing on the effectiveness of vegetated buffer strips in reducing stream sedimentation following timber harvest activities have centered on road systems because they are the primary source of sedimentation in streams (Belt et al. 1992; Lloyd 1985; Osborne and Kovacic 1993, however, see results from PWA 1998A, 1998B below). In addition to width, particle size and surface drainage, other factors important in determining the efficiency of buffer strips include micro- and macro-relief, vegetation type and density, soil and leaf litter characteristics, subsurface drainage and slope (Gough 1988). Moring (1987) examined the impact of timber harvest activities on gravel sedimentation. Gravel sedimentation was linked to a decrease in habitat conditions for developing salmonid eggs and alevins. He determined that the use of 30 meter vegetated buffer strips can reduce the filling of gravels with fine sediment following timber harvest activities.

The efficiency of buffer strips in controlling road related sedimentation is affected by the travel distance of the sediment moving off of the road (Belt et al. 1992). Sediments moving directly off a road fill onto a buffer strip can be maintained by a fairly narrow buffer. For example, Osborne and Kovacic (1993) examined the use of riparian buffer strips in managing non-channelized sediment inputs to the streams. The studies they reviewed found that sediments from logging roads could be effectively managed using buffer strips ranging from 9 m in Idaho, to 15 m on gentle slopes in New Hampshire. By contrast, sediments that are routed to roadside channels that collect runoff drainage before moving into a buffer, require a wider buffer strip (Belt et al. 1992), or cannot be controlled by buffer strips (USDA 1993). Johnson and Ryba (1992) concluded that only buffers which maintain overland flow as unchannelized sheetflow are effective. Similarly, Belt et al. (1992) reported that sediment from drains can travel more than 313 m given adequate flow.

Most of the studies reviewed above examined sediment from surface erosion off of roads and disturbed soils. Overall, these studies indicate that vegetation within RMZs can be very effective in preventing sediment delivery to streams if: (1) the slope is not excessive, (2) the sediment is dispersed as overland flow or dry ravel rather than in channelized flows, and (3) the buffer is sufficiently wide. With respect to item 3, most studies have concluded that buffers 100 ft. or greater in width are sufficient to prevent sediment delivery to streams. Thus, the 170 ft. and 100 ft. RMZs proposed by PL for Class I and Class II streams, respectively, are likely to be very effective in preventing delivery of fine sediments from roads and disturbed areas. These buffers will contain both “no-cut” areas and late seral stands, both of which will have a high density of vegetation, limited (or no) management disturbance, and numerous measures designed to reduce sediment production and transport. Similarly, Class III streams, while not subject to a buffer retention requirement, do include mitigation measures to reduce sediment delivery to streams. Examples of RMZ measures designed to reduce sediment delivery include:

- All harvest in late seral zones is single tree only with no more than 1 entry every 20 years. In addition, as noted earlier, because of severe restrictions on when harvest can occur, many late seral zones will not be “eligible” for any harvest for decades.
- When harvest does occur, no equipment is allowed within the RMZs to ensure that soil disturbance is kept to a minimum.

- Yarding of harvested trees must utilize full suspension methods to the extent practicable. Thus soil disturbance associated with dragging logs will be avoided in most cases.

- Class III streams have slope dependent equipment limitation (ELZ)/equipment exclusion (EEZ) zones to reduce disturbance.

- All downed wood with the Class III ELZs/EEZs must be retained in place.

- No fires can be ignited within the Class III ELZs/EEZs.

The above HCP measures are focused primarily on maintaining the integrity of vegetation and soils within RMZs to increase sediment filtering effectiveness. However, PL has also proposed HCP measures that will reduce the production of fine sediments particularly from roads. (Note - the effectiveness of road-related measures on mass wasting related sediment inputs is discussed in the next section.) By reducing the amount of sediment reaching RMZs, the company will reduce sediment delivery to streams, regardless of the sediment filtering effectiveness of the retained buffer strips. These "source reduction" measures for fine sediment include:

- Storm proofing of all existing roads on PL's ownership at the rate of 500 miles/decade. PL has agreed to correct all high and medium priority sites as part of this Plan.

- All new roads and reconstructed roads will be built and maintained to storm proof standards.

- Wet weather closure standards will be used to prevent hauling and heavy truck use of roads during periods when fine sediment erosion is more likely.

- Within RMZs, any area of disturbed soil greater than 100 ft^2, if due to management activities, will be treated to prevent erosion. Areas smaller than 100 ft^2 will also be treated on slopes greater than 30 percent if they are likely to lead to sediment delivery to streams.

- PL's entire active road network will be inspected yearly for "problems" with all remedial work to be conducted before the onset of the next winter rainy period.

Although roads are not the only source of sediment, they are widely believed to be one of the largest sources. This belief is due to both PL's past "on the ground" experience, and significant scientific research demonstrating the large impact of roads on sediment budgets in forested watersheds (WADNR 1995). For example, Furniss et al. (1991) found that impacts to streams and fisheries can be 1-2 orders of magnitude higher from the construction and maintenance of roads than from any other forest land management activity. Similarly, Sidle et al. (1985), in an analysis of mass wasting originating from various land use activities found that mass soil movements are 30 to more than 300 times more likely to be associated with forest roads than with any other disturbance. A final example is an EPA report on forest management activities in the Bull Run watershed in Oregon which showed that approximately 70 percent of the sediment recruited to streams resulted from roads (EPA 1975).

Recent research on PL's lands by Pacific Watershed Associates (PWA 1998A, 1998B), while confirming the importance of roads as a source of management related sediment, have demonstrated that roads may constitute only a small portion of the total sediment budget. For example, in the Bear Creek Watershed, only 8 percent of sediment originated from roads, and of that, only 12 to 25 percent (or 1% to 2% of the total) was due to surface erosion. These same studies confirmed that mass wasting is both the dominant sediment source, and that rates of landsliding are high even in areas that have not been actively managed. A similar set of conclusions were developed by Pyles et al. (1998) in their review of studies for the Oregon Coast Range. However, although roads may represent a minority of the total sediment delivered to streams, they may constitute a large fraction, or even the majority of the sediment reaching streams because of PL's activities.

Given that roads are an important source of sediment being generated by PL's management activities, the proposed road related HCP measures are expected to have a significant positive impact in reducing sediment inputs to streams on the ownership. Quantification of this benefit will be evaluated further in the future as part of the sediment budget development associated with the road storm-proofing and watershed analysis efforts. However, based on the studies cited above, PL's road related HCP measures could be expected to reduce management related sediment inputs to streams by anywhere from 25 to over 75 percent. Reductions of this magnitude are expected to result in significant positive changes in the quality and abundance of spawning and rearing habitats used by fish in streams on the ownership. Because the road armoring process will take several decades to complete, and because it will take time to remove existing sediment accumulations, this benefit is expected to begin slowly and then steadily increase over the life of the Plan.

Given both the expected benefit of PL's RMZs in preventing sediment delivery to streams, and the source reduction measures proposed to minimize sediment production, it seems likely that PL's HCP will significantly reduce sediment delivery to streams compared to delivery rates that are occurring under current practices. Studies on buffer effectiveness suggest that interception of fine sediments, if not in channelized flow, could approach interception levels in unmanaged forests. Quantifying the benefit of PL's source reduction measures is more difficult. However, the company has committed to source reduction efforts that significantly exceed those required under state rules, and are arguably more restrictive than those adopted by any other timber company in the Pacific Northwest.

1.3.1.6. Sediment Input-Mass Wasting

As noted above, management activities can result in sediment transport to streams via two mechanisms, surface erosion and mass wasting. Mass wasting (e.g., landslides) can deliver significant quantities of sediment to streams, and are very common in the geologic conditions present on PL's ownership (Kelsey 1980, PWA 1998a, 1998b). This mass delivery of sediment can widen streams, fill pools, increase turbidity, and generally reduce habitat quality.

Determining the effect of roads on mass wasting related sediment delivery is relatively easy. Road related landslides usually initiate at the cut or fill slope for the road, or at places where the road crosses streams. Thus, a field or photographic review of landslides will usually identify a road at or adjacent to the initiation site of the mass wasting feature being examined. Since roads are not natural, any road related mass wasting feature is, by definition, due to management.

Determining the impact of management on mass wasting rates from harvested areas, by contrast, is much more difficult (Pyles et al. 1998). This is because mass wasting occurs frequently along the north coast of California regardless of management history (Kelsey 1980, PWA 1998A, 1998B) even in unmanaged forests. Thus is often not possible to tell whether an individual landslide occurred because of some harvest related factor or because of natural conditions (Pyles et al. 1998). Given this and other difficulties (see section on effectiveness monitoring for additional discussion), a common approach to assessing the effects of management on mass wasting is to compare the number and size of mass wasting features in managed and unmanaged areas. To the extent that mass wasting is higher in the managed area than in the unmanaged "control," the difference is assumed to be due to management effects.

Quantifying the increase in landsliding due to management is informative, but has limited utility is the design of a HCP. Of greater importance is identifying where landslides are occurring, what conditions are associated with the failures, and, most importantly, how can management be modified to reduce the rate of mass wasting? Answering these types of questions requires an extensive sediment source study. And because geology, climate, topography, and management techniques are all important in determining the frequency and types of mass wasting events (WADNR 1994), these types of sediment source studies are typically specific to the areas where they are performed (Pyles et al. 1998). Put another way, it is difficult to extrapolate the results of a sediment source study to areas that don't share similar physical characteristics and management histories.

PL is fortunate that two separate sediment source studies have recently been conducted for lands within its ownership (PWA 1998A, 1998B). PWA 1998a is a sediment source study prepared under contract to the Environmental Protection Agency. This study examined the relative contribution of sediment delivered to stream channels from various erosional processes on hillslopes within a 350 mi^2 area covering the lower Van Duzen and Eel river watersheds. This study area covered the Yager WAA, and portions of the Eel and Van Duzen WAAs (see Section 1) and included analysis of aerial photographs from 1966, 1974, and 1994. A more intensive field verification of road erosion was conducted, exclusively, on PL's lands. The study found that, on average, 59.2 percent of the area covered by mass wasting features ("sediment delivery area") occurred in inner gorge slopes. Inner gorges, as used in the study, were slopes greater than 65 percent that occurred adjacent to stream channels. On average, an additional 21.3 percent of the sediment delivery area was associated with streamside landslides, and an additional 5 percent were streambank failures. Thus, 85 percent of the sediment delivery area occurred in or adjacent to streams, especially where slopes exceeded 65 percent. The study also found that a relatively small number of watershed basins (4) were responsible for most of the quantified mass wasting (84 percent).

PWA 1998a also examined the association between mass wasting features and management history. The study found that, on average, 20.1 percent of all landslides occurred in unmanaged areas. An additional 13.3 percent occurred in areas that had not been managed in greater than 35 years, and where, therefore, "...it would be difficult to attribute landslides within these areas to past forest harvesting" (PWA 1998a, pp. 13). Thus, a third of all landslides occurred in areas where the influence of PL's management was low or non-existent. The second part of PWA's study, the field survey, found that 50 percent of all non-road related mass wasting was associated with unmanaged sites. Unfortunately, the study did not quantify the proportion of the study area composed of different land types, so it is not possible to determine a "background" mass wasting rate from these data. PWA also found that 26.9 percent of all landslides occurred in areas subject to tractor clearcutting more than 15 years in the past, and an additional 18 percent occurred along skid trails and roads. The field study found that 20 percent of the total sediment yield was road related. The authors concluded that based on personal experience, these road related figures are underestimates. Areas subject to cable yarding and/or partial harvest always had a low number of sediment delivery areas, regardless of the photo set examined.

PWA 1998b examined sediment sources in the Bear Creek watershed, an 8 mi^2 basin that drains into the lower Eel River. The watershed is almost wholly owned by PL. This sediment source study was similar to the PWA 1998a study except that field assessment of mass wasting features and sediment delivery rates were much more extensive. The results are therefore more complete and quantitative than the earlier study. Aerial photographs from 1946, 1966, 1974, 1994, and 1997 were examined. Based on photo analysis and site visits the study's authors concluded that over 75 percent of all sediment delivery to streams originates from large landslides. Photo analysis of the watershed under old growth conditions in 1947 revealed 10 such landslides. The comparable area observed in the 1997 photos had 11. Thus, the number of large landslides under PL's current management regime is virtually unchanged from the number observed under old growth conditions. The average volume of sediment delivered per large slide was also comparable between the two periods.

As for location, PWA 1998b found that 69 percent of all landslides originated on inner gorge slopes, and an additional 13 percent originated from streamside areas. Roads accounted for only 8 percent of all sediment delivered to steams. These results are very similar to those observed in PWA 1998a, and confirm that inner gorge and streamside areas, not roads, are the most important sites for mass wasting related sediment on the portions of PL's ownership assessed by these studies. The authors also estimated that surface erosion, as opposed to mass wasting, was responsible for only 1-2 percent of the total delivered sediment. Finally, the study documented that the rate of mass wasting and sediment delivery has decreased dramatically over time. The authors report that "...data collected for this investigation strongly suggest that the Forest Practice Rules, as well as recent changes in road location, road construction and harvesting techniques...are having a measurable and significant effect on reducing the long term sediment yields." The study noted however, that sediment delivery rates in the most recent time period still exceed those estimated to have occurred under old growth conditions [the authors note, however, that the absence of large storms immediately prior to the old growth photo series

(1947) and the difficulty in seeing small slides under old growth conditions may have led to underestimation of total sediment delivery for the pre-management period].

Collectively, PWA 1997 and 1998 can be used to assess important aspects of mass wasting on PL's lands. These include:

- Many landslides occur on PL's lands regardless of management history. These "natural" landslides can constitute the majority of all sediment delivered to streams.
- Inner gorge areas are, by far, the most important site for mass wasting events. Further, most such landslides originate in inner gorge areas near the streams; an analysis of data in PWA 1997 (provided to PL by EPA) found that 93 percent of all such inner gorge landslides originated within 400 ft. of streams (PL unpublished analysis).
- Streamside areas are the second most important site for mass wasting. Both streambank erosion, and failures of side slopes adjacent to streams are important sediment sources.
- Roads are much less important as sediment sources than would be expected given results of other studies (e.g., Burns 1970; Cederholm et al. 1981). However, road-related sediment represents a large proportion of the sediment that can clearly be attributed to management activities.

PL is currently conducting sediment source surveys for its Elk River, Jordan Creek, and Stitz Creek watersheds. Results of these studies, which are due in early summer 1998, will provide additional information on both sediment sources, and the importance of PL's management activities in producing sediment. However, the studies conducted to date can be used to assess the effectiveness of PL's MSCHP measures in reducing mass wasting related sediment. PWAs work indicates that mass wasting will continue to occur at a significant rate on the ownership, regardless of the management actions of the company. However, PL's proposed HCP measures should be very effective in reducing the amount of mass wasting that would otherwise occur in the future if current management practices are continued:

- The Plan proposes to require site reviews by a geologist of inner gorges, extreme hazard slopes, headwall swales, and currently unstable areas before any new harvest or road building can occur. Thus, PL is proposing geologic review of areas that collectively represent over 65 percent of all mass wasting sites.
- Similarly, the Plan requires review by a geologist before new roads or operation of heavy equipment other than on existing roads can be conducted for any very high or high hazard areas for mass wasting. This proposal means that geologic review will be extended to include over 25,000 acres of additional lands on the ownership.
- PL has proposed 170 ft., and 100 ft. riparian buffers for Class I and Class II streams, respectively. These buffers are equipment exclusion zones, with minimal (or no) tree harvest, requirements for full suspension yarding, etc. Thus, the areas responsible for the second largest category of mass wasting features, streamside areas, will be provided with extensive protections against road and harvest related impacts.

- PL has agreed to storm proof all 1,500 miles of roads on its ownership. Road storm proofing will significantly reduce the incidence of mass wasting features from roads, thereby minimizing one of the largest sources of management related sediment delivered to streams.

Overall, the logging and road related HCP measures proposed by PL are expected to reduce most of the impacts of these activities on aquatic resources. As detailed above, the HCP measures have a high probability of producing conditions favorable for aquatic resources in Class I and Class II streams. These conditions include high streamside shade levels, cool water temperatures, bank and stream channel stability, recruitment of LWD to streams, particulate organic matter production, and development of complex in-channel habitats for fish.

1.3.2. Anticipated Effectiveness of HCP Mitigation Measures for Rock and Gravel Mining

Rock Quarrying

As stated in Subsection 1.2.3 hardrock mining is not expected to result in impacts to creeks or riparian areas on the property. The quarries and surrounding areas will be analyzed further during the watershed analysis process. This will provide the company with an opportunity to identify any necessary future mitigations at that time.

Near Stream Gravel Mining

Mining is already highly regulated by several agencies. Due to the fact that riparian mitigations are agency regulated, gravel mining is expected to have no negative impacts on this resource. Our conclusion that mitigation measures for fisheries are sufficient is supported by NMFS issuance of an Incidental Take Statement covering PL's gravel extraction operations.

1.3.3. Anticipated Effectiveness of HCP Mitigation Measures for Grazing

Current mitigation measures should be adequate to keep cattle from concentrating in the creeks and otherwise having a significant impact on aquatic resources. Grazing in specific watersheds will be evaluated as part of the watershed analysis process. If watershed evaluations indicate that grazing is having an adverse effect on aquatic resources, additional mitigation measures will be considered during the prescription writing phase of watershed analysis. Mitigating prescriptions that could be considered are: fencing of streams to prevent access, rotation of periods of grazing with periods of rest, cesation of all grazing and provision of alternate sources of water (other than watercourses).

1.3.4. Anticipated Effectiveness of HCP Mitigation Measures for Instream Habitat Improvements

As discussed in Subsection 1.2.5 the expected comprehensive effect of this activity will be strongly positive. The instream habitat improvements are anticipated to greatly enhance fishery and amphibian resources.

1.3.5. Anticipated Effectiveness of HCP Mitigation Measures for Fish Rearing Facilities

Since PL's fish rearing facilities are primarily for the purposes of aiding in the establishment of self-sustaining populations of wild fish, the facilities will only be used as long as they are thought to be having a positive impact on wild fish populations. PL believes that, with the improved methodologies in place, the fish rearing and release program will help maintain and restore the fisheries resource. These measures will reduce transmission of disease, inferior genetics, and negative interactions between wild and hatchery fish. Given this, the fish rearing and release program will have an overall positive impact despite some negative potential. Both NMFS and CDF&G are involved in yearly evaluation of the hatchery as part of the license renewal process. This process will provide an ongoing opportunity to evaluate program benefits and problems.

1.3.6. Anticipated Effects of Watershed Analysis

No mitigation measures are proposed for watershed analysis since it will have no negative impacts. For the most part, watershed analysis is conducted using maps, aerial photographs or by walking roads. The most intrusive activity is field verification of instream conditions and these impacts are negligible (see Subsection 1.2.9). However, aquatic resources are expected to benefit greatly as a result of watershed analysis. Watershed analysis synthesizes the best science available with the resource conditions that currently exist on the land. A team of experts works both on the assessment of land conditions as well as on how to address those conditions. The result is development of "site specific" mitigation strategies that are "customized" to local conditions. This application of science to development of customized resource protection strategies is the best possible approach to maintaining and restoring fish and amphibian habitat. Application of the watershed analysis is, therefore, anticipated to have strongly positive results on PL property.

1.3.7. Anticipated Effects of Scientific Surveying and Monitoring

Impacts to fish populations from scientific surveys and monitoring efforts are expected to be minor, and would likely be limited to small disturbances to instream habitat associated with the data collection effort. Significant positive impacts from these monitoring efforts would be expected because data from these scientific collections will be used to ensure that the Plan is promoting the protection and restoration of fish populations (see Subsection 2.2).

1.3.8. Anticipated Effects of Headwaters/Elk Springs Land Transfer

By converting these areas of commercial timberland to state/federal park lands, road construction and harvest will not occur here. Therefore, there is no potential for negative management related impacts to these areas. If this land were not set aside, activities that would have required mitigation, such as road construction and harvest activities would have occurred. This transfer results in significant positive impacts to these areas.

1.3.9. Anticipated Effects of HCP Mitigation Measures on Trout and Salmon

Existing conditions within many streams of PL's ownership are not ideal for trout and salmon. For example, fine sediment levels and water temperatures in many stream reaches are higher than those preferred by salmonids. Moreover, the abundance of pools, other deep water habitats, and instream cover are below ideal levels in many locations (Volume II, Part H). Assessing the potential effect of the Plan for trout and salmon, therefore, involves determining the extent to which the proposed measures will improve upon, or at least prevent further deterioration of, existing conditions important to fish.

As discussed above, the Plan measures are expected to increase the abundance of deep water habitats and instream cover, maintain or reduce water temperature, and improve conditions in gravels used for spawning, and as prey production areas. These expected changes will be beneficial for trout and salmon. In addition, growth rates, the number of fish supported by individual stream reaches (i.e., carrying capacity), and overall survival rates are expected to increase over current conditions.

Instream restoration and hatchery supplementation should also improve trout and salmon production. However, the benefit of these measures is secondary to the permanent benefits of the road and timber harvest related HCP measures.

1.3.9.1. Chinook Salmon

Measures within the Plan are expected to have a substantial positive impact on chinook salmon populations on PL's ownership (Table 6). Because only "ocean-type" chinook salmon are present within PL's ownership, the largest anticipated effects of the HCP measures for chinook would be for the adult holding and spawning life history stages. This somewhat restricted stream residency limits the number of HCP measures that are expected to have a significant effect on the survival of chinook salmon. The measures anticipated to have the largest effect on chinook survival include a reduction in fine sediment input from roads and harvest activities, increased recruitment of LWD through increased retention of large, nearbank, riparian trees and stabilization of streambanks.

A reduction in fine sediment input and an increase in LWD input would offer several benefits to chinook salmon including decreasing percent fine material, increasing or stabilized sediment, and increased frequency and maximum depth of deep water areas. Specific examples of how the proposed HCP measures will positively affect chinook salmon populations are presented below:

- As with all other salmonids, chinook salmon fry survival to emergence is affected by the percent of spawning gravels composed of fine sediments <0.85 mm in size (Shepard et al. 1984; Chapman 1988; Bjornn and Reiser 1991; Young et al. 1991). Pl's management measures are designed to maintain percent fine sediment levels at or near baseline/unmanaged conditions which, where found within the ownership (e.g., Lawrence Creek), are currently producing high fish production.

Table 6 Species specific checklist of the management activities and MSHCP measures that are expected to affect fish species within PL's ownership.

HCP Potential Management Impacts and Mitigation Measures	Candidate Species for Listing				Other Fish Species			
	Chinook salmon	Coastal cutthroat trout	Coho salmon	Steelhead trout	Eulachon	Green sturgeon	Longfin smelt	Tidewater goby
Management Activities Potentially Impacting Fish								
Logging	X	X	X	X	X	X	X	X
River bar gravel mining	X	X	X	X	X	X	X	X
Grazing	X	X	X	X				
Instream habitat improvement	X	X	X	X				
Hatchery	X	X	X	X				
Scientific surveys and monitoring	X	X	X	X		X		
HCP Measures[1]								
Riparian Buffers	short/long	short/long	short/long	short/long	short/long	short/long	short/long	short/long
LWD recruitment and protection	long	long	long	long				
Instream habitat improvement and hatchery	short	short	short	short	short	short	short	short
No gravel operations in wetted channel or WLPZ	short	short	short	short	short	short	short	short
Road construction and armoring specifications	short/long	short/long	short/long	short/long	short/long	short/long	short/long	short/long
Less than 20% disturbance index2	short	short	short	short	short	short	short	short
Scientific surveys and monitoring	long	long	long	long	long	long	long	long
Headwaters/Elkhead Springs old growth reserve	short/long	short/long	short/long	short/long				

1 Short refers to improvements expected to take effect in 25 years or less following implementation.
Long refers to improvements expected to take effect in greater than 25 years following implementation.

- Reductions in fine sediment levels generally result in a corresponding increase or roughening of channel substrate material (Leopold et al. 1964; Lisle 1982). As mentioned in Volume IV Part D Section 2, the large body size of chinook salmon allows for the utilization of larger gravel and cobble substrates (Raleigh et al. 1986). PL's proposal to maintain or increase channel roughness are expected to result in increases in both the quantity and quality (size) of suitable spawning gravels offering additional and higher quality spawning areas.

- In most alluvial stream channels, the frequency of large, deep pools are controlled by the amount of LWD found within the active channel (Bilby and Ward 1989; USDA 1993; Keller et al. 1995a). Localized scour of bed material associated with LWD and debris jams results in the formation of large, deep water pools (Keller and Tally 1979; Lisle 1986). As discussed earlier, PL's HCP measures are expected to result in increased recruitment of LWD to the channel, reduced input of fine and coarse sediment that can fill pools, and maintaining bank stability leading to a narrowing and deepening of some additional channel areas. Increased frequency and depth of large pools and other channel areas are expected to provide additional holding areas for migrating adults.

PL's proposed management measures for the reduction of sediment input from road and harvest activities and the increased retention of riparian trees for recruitment as LWD are anticipated to have a net positive impact on chinook salmon production within PL's ownership. These measures are expected to result in increased adult holding habitat, reduced fine sediment levels, and increases in both the quantity and quality of chinook spawning gravels.

1.3.9.2. Coho Salmon

Measures within the Plan are expected to have a substantial positive impact on coho salmon populations on PL's ownership (Table 6). Coho salmon juveniles generally reside within streams for a year or more, and are particulary dependent upon instream cover, deep water areas, and cold water temperatures (Bustard and Narver 1975a, 1975b; McHahon 1983; Sandercock 1991). Particular HCP measures that are expected to have a significant impact on the survival of coho salmon include increased retention of large, nearchannel riparian trees and reduction in sediment input from roads and harvest activities.

PL recognizes that providing adequate LWD levels in ownership streams is particularly important for coho survival. Increased retention of riparian trees will benefit coho survival by increasing the frequency and complexity of pool habitats and by providing streamside shade for control of water temperature. A reduction in fine sediment input would benefit coho salmon by decreasing percent fine material in spawning gravels and by reducing aggradation of pool areas. Specific examples of how the proposed HCP measures will positively affect coho salmon populations are presented below:

- The survival of young coho salmon is closely related to the frequency of in-channel LWD and associated pool habitat (Mason and Chapman 1965; Lisle 1986; Shrivell 1990; Steele and Stacey 1994). In most alluvial stream channels, the frequency and size of pools are controlled by the amount of LWD found within the active channel (Bilby and Ward 1989; USDA 1993; Keller et al. 1995a). PL has established limited management and additional late seral management prescriptions for RMZ areas adjacent to all Class I and II streams to ensure a high level of potential LWD recruitment. PL's management measures are expected to maintain or increase the proportion of a stream's length comprised of pools. Additionally, the management measures will increase or stabilize the average volume of instream LWD. This measure is expected to have the most significant positive impact on the production of coho salmon within PL's ownership.

- As noted elsewhere in this Plan, existing data and previous studies indicate that some streams within the ownership reach high water temperatures during the summer, and probably did so even under pre-management conditions. Given the temperature sensitivity of coho juveniles, PL's proposed RMZ management measures are expected to provide approximately the same level of streamside shade as occurred under pre-management conditions. These measures are expected to maintain water temperatures within reach or basin potential conditions.

- As with chinook salmon, coho salmon fry survival to emergence is affected by the percent of spawning gravels composed of fine sediments <0.85 mm in size (Shepard et al. 1984; Chapman 1988; Bjornn and Reiser 1991; Young et al. 1991). PL's management measure are designed to maintain percent fine sediment levels at or near baseline/unmanaged conditions.

- As discussed earlier, the frequency of large, deep pools are controlled by the amount of LWD found within the active channel (Bilby and Ward 1989; USDA 1993; Keller et al. 1995a). When compared to chinook salmon, the somewhat smaller body size of coho salmon allows migrating adults to hold in correspondingly smaller pools. Consequently, the same management measures that would result in increased large, deep pools for chinook are expected to provide additional space for coho salmon.

PL's proposed management measures for the reduction of sediment input from road and harvest activities and the increased retention of riparian trees for recruitment of LWD and to provide streamside shade are anticipated to have a net positive impact on coho salmon production within PL's ownership. These measures are expected to result in increased juvenile rearing habitat, and adult holding habitat, reduced fine sediment levels, moderate water temperatures, and increases both the quantity and quality of coho spawning gravels.

1.3.9.3. Steelhead Trout/Rainbow Trout

Measures within the Plan are expected to have a substantial positive impact on steelhead/rainbow trout populations on PL's ownership (Table 6). Although less dependent on pools and instream cover than coho, steelhead and rainbow trout will still benefit from improvements in deep water areas, cover, and LWD loading. In addition, given their multi-year (steelhead) or permanent (rainbow) residency within streams, these improvements will affect a significant portion of the life cycle of these species. Although all of the proposed HCP measures are assumed to have a positive effect on steelhead and rainbow trout, the retention of riparian trees is anticipated to have the greatest effect. Mature riparian trees will provide thermal insulation and maintain LWD loading, which in turn will provide cover and pool habitat. Specific examples of how the HCP measures will affect steelhead and rainbow trout are presented below:

- PL's proposed prescriptions for riparian buffers along Class I and II streams are anticipated to result in decreased solar stream heating within the ownership. PL has provided for a minimum of 170 ft buffers on fish bearing streams. This is a conservative width in comparison to the conclusions by FEMAT that a 30 meter wide buffer would provide as much thermal shading as an old growth forest (USDA 1993). Steelhead/Rainbow trout will benefit from the cooler temperatures provided by this shade. The protection and improvement of water temperatures measures could be especially important for the eggs/larvae of this species, which would be present during warmer periods of the year. Overall, PL's proposed RMZ management measures will provide approximately the same level of streamside shade as occurred under pre-management conditions.

- Another benefit from PL's retention of riparian trees is the anticipated increase in LWD recruitment. LWD provides cover directly (e.g., from submerged root wads), and leads to the formation of pools and surface turbulence that provide instream cover to fish. As mentioned for other species, the HCP measures provide both "no-cut" and late seral management prescriptions for RMZ areas adjacent to all Class I and II streams to ensure a high level of potential LWD recruitment.

- Bisson et al. (1988) found juvenile steelhead and rainbow trout to display a preference for pools containing localized areas of swift water. The frequency of large, deep pools are controlled by the amount of LWD found in the channel (Bilby and Ward 1989; Keller et al. 1995a). Increased LWD will also lead to narrowing and deepening of the channel, providing additional swift water areas of pools that juvenile steelhead prefer.

The cumulative effect of the proposed HCP measures are expected to have a positive impact on the production of steelhead and rainbow trout.

1.3.9.4. Coastal Cutthroat Trout

Measures within the Plan are expected to have a substantial positive impact on both anadromous and non-anadromous populations of cutthroat trout on PL's ownership (Table 6). Increases in deep water habitat, instream cover, and improved spawning gravel conditions will all enhance production of this species. Because juvenile cutthroat trout reside within streams for several years (sea-run) or permanently (resident cutthroat), these habitat improvements will affect a significant portion of the life history of this species. In addition, many of the positive impacts affecting steelhead and rainbow trout will also play important roles in the life history of cutthroat trout.

Providing adequate LWD on PL's ownership will positively affect cutthroat trout population in many ways. Although they have been discussed in detail for other similar species some specific examples of how HCP measures concerning LWD and sediment input will affect cutthroat trout are presented below:

- By maintaining LWD levels additional instream cover will result which is expected to increase the survival and total production of cutthroat trout. Cover provides protection from predators, as well as providing a greater number of microhabitats for individual fish to occupy. Both of these factors are anticipated to increase the number of cutthroat trout.
- The frequency and size of pools is controlled by the amount of LWD found within the active channel (Bilby and Ward 1989; USDA 1993; Keller et al. 1995a). This will increase the habitat for juvenile trout, particularly for over-wintering and summer-time cool water refugia (ODFW 1995).
- PL's management goal to minimize the percentage of fine sediment within spawning gravels will increase both the quality and quantity of suitable spawning gravels. As with other salmonid species, cutthroat fry survival to emergence is affected by the percent of spawning gravels composed of fine sediments <.85 mm in size (Shepard et al. 1984; Chapman 1988; Bjornn and Reiser 1991; Young et al. 1991).

The cumulative effect of the proposed HCP measures is expected to have a positive impact on the production of steelhead and rainbow trout.

1.3.10. Effects of the HCP Measures on Other Fish Species

The discussion above outlines the major changes to stream conditions and water quality expected to result from the proposed HCP measures. The impact of these changes to fish other than trout and salmon varies because of the differing life history requirements of these species. In general, coastrange sculpin, prickly sculpin, Sacramento sucker, Pacific lamprey, and threespine stickleback have at least some habitat and water quality requirements similar to those for salmonids. Consequently, the HCP's measures are expected to have some positive effects on these species. California roach, and Sacramento squawfish, by contrast, generally prefer or require conditions that differ from those considered optimal for salmonids.

1.3.10.1. Coastrange Sculpin, Pacific Lamprey, Prickly Sculpin, Sacramento Sucker, Threespine Stickleback

These species share at least some of the same habitat and water quality preferences/requirements as trout and salmon. Consequently, measures within the Plan are expected to have some positive impact on these species. For example, four of the species will benefit from reductions in fine sediment levels that would increase the coarseness of spawning (lamprey) or spawning and feeding (sculpins, sucker) substrates. Similarly, Sacramento suckers, coastrange sculpin, and threespine stickleback prefer cool water temperatures, and would presumably benefit from those HCP measures that would reduce water temperatures. Prickly sculpin is a habitat generalist that is not expected to be significantly affected by the Plan either positively or negatively. Sacramento suckers, by contrast, have habitat preferences that encompass many of the same conditions as those preferred by trout and salmon. Consequently, the proposed HCP measures should have a positive effect on populations of this species.

The Plan is expected to have at least some negative consequences for Lamprey because this specis' juveniles rear in areas with sand and silt substrates, but the Plan should reduce the abundance of these substrate types in many streams. However, as noted above, reductions in stream sediment levels will increase the quality of spawning areas used by Pacific lamprey. This should lead to increased survival rates of eggs and young juveniles. In addition, extensive areas with sand and silt substrates are available in the lower reaches of many streams (i.e., downstream of PL's ownership). Consequently, rearing habitat for Pacific lamprey is not expected to be substantially decreased as a consequence of this Plan. Increased shading levels in riparian zones if the Plan is implemented would reduce the abundance of aquatic vegetation. However, many of the streams on PL's ownership have downstream sections off the ownership that are characterized by low gradients, limited overhead canopy, and sand/silt substrates (e.g., Freshwater Creek, Elk River). These areas are likely the most important habitats for lamprey already, especially given the proximity of these areas to estuarine habitat. If the Plan is implemented the importance of these habitats would increase.

1.3.10.2. California Roach, Sacramento Squawfish

California roach and Sacramento squawfish prefer warmer water temperatures than do trout and salmon (Moyle 1976) and roach also require filamentous algae for food. Thus, although certain habitat changes (e.g., increases in deep water holding areas) could have benefits for these species, the increased shade levels and reduced water temperatures expected to result from the HCP measures are likely to adversely affect these two species. However, both species have been introduced to the Eel River basin and are generally considered to be "pest" species that compete with or prey upon native fish. Consequently, changes in habitat or water temperatures that negatively impact these species may actually constitute a net positive impact on the native fish populations on PL's ownership.

1.4. ANTICIPATED EFFECTS OF THE PLAN ON COVERED AMPHIBIAN AND REPTILE SPECIES

Amphibian and reptile species have only been minimally addressed in this section since they are discussed in greater detail in Volume IV, Part E. Since there are covered species that are dependent on riparian areas for various stages of their life history, the aquatic conservation strategy is quite relevant to these species. These species (foothill yellow-legged frog, red-legged frog, tailed frog, southern torrent salamander and pond turtle), as a group, have several habitat requirements, including, but not limited to:

- Cool air temperatures (<22^{o} C)
- Cool water temperatures (5 ^{o} C to 17.2 ^{o} C)
- Soil temperature of <14^{o} C
- Relative humidity >40%
- Large woody debris (LWD) in the stream channel and in the riparian zone
- Clean, undisturbed gravel and cobble
- Limited disturbance within 5 meters of the stream bank

Each of these habitat requirements is expected to be provided for through the implementation of the aquatic conservation strategy in the Plan. Establishment of the Riparian Management Zones (RMZ) with no cut and late seral zones will be effective in maintaining stable air and soil temperatures as well as maintaining suitable relative humidity levels. Protection of channel migration zones is highly likely to ensure that important rearing habitat for these species is conserved. High canopy cover levels in the RMZ will protect water temperatures from rising. PL's aquatic conservation strategy also provides for extensive recruitment of LWD in streams, channels and within riparian forests. LWD in the stream channel will provide cover for egg masses, larvae, and adults. Down wood in the riparian zone will provide habitat for adults. In addition to natural introduction of LWD, fish habitat improvement projects frequently add LWD and rootwads to the stream channel. Overall, the establishment of RMZs and retention of LWD will maintain the microclimate and microhabitats desired by amphibians.

A combination of efforts will work towards providing clean, undisturbed gravel and cobble for amphibian use. By keeping equipment out of the wetted channel during gravel extraction, disturbance to the amphibians in the stream channel will be limited. The roads and mass wasting strategy will prevent introduction of large quantities of sediment, including fine sediments that fill the interstitial spaces necessary for egg survival. The width of the RMZs will also provide for fine sediment settlement from runoff. Finally, extensive sediment monitoring will be conducted to ensure that fine sediment mitigations are effective. This combination of actions will only increase the availability of clean, undisturbed gravel and cobble for amphibians.

Within the RMZ, 30' of the Class I and 10' of the Class II stream buffers will be designated as Restricted Harvest Bands (RHBs). The only activity allowed here is harvest to enhance and facilitate riparian functions. In most cases, this means that the zone will remain undisturbed. All of the covered amphibians make extensive use of areas very close to the stream channel. No activity within the RHB should eliminate the possibility of direct impact on amphibians due to equipment and harvest activity.

Besides these measures being taken on Class I and II streams, Class III streams have protections that will also be beneficial to amphibians. No burning within 25' of the stream edge, no removal of down wood, and equipment limitation zones within 25' of the stream edge are measures that are applied to all Class III streams. Additional measures are applied based on the side slopes of the stream. The benefits of fine sediment reduction, presence of down wood and equipment limitation zones have been discussed above.

Overall, the aquatic conservation strategy has a high probability of having significant positive impacts on covered amphibian and reptiles, providing for greater habitat quantities and quality, and a significant reduction in disturbance levels compared to those permitted under existing rules. These positive impacts are discussed more specifically for each of the species in Volume IV, Part E.

1.5 ANTICIPATED EFFECTS OF THE PLAN ON PROPOSED CRITICAL HABITAT DESIGNATION FOR COHO SALMON

The NMFS is currently considering the designation of critical habitat for coho salmon. The area of the proposed critical habitat designation proposed for the Southern Oregon/Northern California Coast ESU of coho salmon (*Oncorhynchus kisutch*) encompasses PL's ownership. The critical habitat includes all waterways , substrate and adjacent riparian zones below longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least one hundred years) (62 FR 62741 25 November 1997). Critical habitat is the specific areas within the geographical area occupied by the species on which are found those biological features essential to the conservation of the species and which may require considerations or protection and specific area outside the geographical area occupied by the species. These known physical and biological features (primary constituent elements) that are essential to the conservation of the species are: spawning sites, food resources, water quality and quantity, and riparian vegetation. Other important features include adequate: substrate, water temperature, water velocity, cover/shelter, space, and safe passage conditions. These features are necessary in small headwater streams, mainstem reaches and estuarine zones. Since the company owns no land surrounding estuarine zones, and the Plan area also does not include any estuaries only the critical habitat elements associated with streams are relevant to this Plan.

Each of the primary constituent elements will benefit from the company's mitigation measures as discussed below:

- Adequate substrate is necessary for spawning habitat. Several measures are proposed that will work to recruit clean gravel for spawning. Fine sediment in gravel inhibits egg survival. The mass wasting avoidance strategy will function to prevent large introductions of sediment to the streams. Road protection measures are aimed at minimizing road failures and fine sediment introduction from road surfaces. Riparian buffers of 170' on class I streams and 100' on class II streams will produce many benefits. One such benefit is that these buffers will minimize fine sediment introduction from surface runoff.

- By decreasing sediment input, water quality, quantity, and velocity may all increase. Water quality is improved by the decrease in fine sediment due to measures described above. Decreases in overall sediment inputs can also increase both water quantity and velocity. Excessive inputs of sediment cause channels to fill in. In less severe cases channels become wide, shallow, and slow-moving. In more severe cases a stream can flowpartially or totally within the deposited sediments (i.e., subsurface) therefore eliminating water from the stream channel. Sediment reduction measures are extensive and should minimize or avoid these negative impacts.

- The features of riparian vegetation, cover/shelter, and wate temperature are addressed by riparian buffers. These buffers maintain the riparian vegetation that helps control water temperatures. This maintenance of riparian vegetation also creates cover and shelter for fish. Cover can be in the form of low growing brush that overhangs the stream channel, trees and branches that fall into the stream, and undercut banks that can develop when trees grow close to the stream channel.
- Both cover and shelter are also provided by instream habitat improvement projects that are planned in many reaches. These are beneficial because the specific features that each reach are lacking are identified and addressed with the project. Often these projects include adding structures that provide cover or placing structures such that cover (i.e., undercut banks) will develop.
- The cover and shelter that are created as described above also function to create space for coho. Coho are territorial fish based on visual cues. By increasing habitat complexity, the number of "hiding spots" is increased which allows more fish to live in an area. This increase in habitat complexity creates microhabitats preferred by coho.
- A combination of the riparian buffer and sediment reduction measures along with those aimed at increasing habitat complexity should increase the food resources available to the fish. Riparian vegetation that grows close to the water increases recruitment of terrestrial insects to the stream. Reduction of fine sediment tends to increase the diversity and abundance of aquatic invertebrates that are a primary food source for coho salmon. Leaf packs typically develop in the structures that create the habitat complexity. Leaf packs are quickly colonized by macroinvertebrates.
- Where it is practical, the company intends to install bridges at all Class I streams crossings to provide fish safe passage conditions. Where bridges are not practical all new crossings will be culverted according to class I fish passage guidelines proposed by NMFS. If actions other than those in these guidelines are proposed the appropriate agencies will be consulted.

Watershed analysis and monitoring, collectively, will ensure that mitigation measures will be applied appropriately and that implementation is effective. The benefit of completing watershed analysis on PL property is that the management strategies can be tailored to the site-specific environmental factors and current influences that exist on the land. Both compliance and implementation monitoring will be performed to ensure that prescriptions are implemented as specified, to obtain a multi-year dataset to track conditions over time, and to assess the effectiveness of management approaches being used by PL to protect aquatic resources. Results of monitoring will be used to modify management strategies when necessary.

Overall, the proposed mitigation measures are expected to result in improved habitat for coho salmon and other fish. Given the many protections for riparian areas and instream habitat, PL does not anticipate that any adverse modification to the proposed critical habitat will occur. This conclusion is based upon the improved conditions that are expected to result from the mass wasting avoidance strategy, sediment reduction measures, riparian buffers, road protection measures, and instream habitat improvement projects. As a consequence, the NMFS has agreed that if critical habitat is designated for any Covered Species and PL is properly implementing the terms of the HCP, the NMFS will not require PL to commit additional conservation or mitigation beyond that provided for under the HCP and this Agreement.

1.6. THE NORTHWEST FOREST PLAN AQUATIC STRATEGY

A 1993 report by the Forest Ecosystem Management Assessment Team or FEMAT (USDA 1993) was instrumental in determining an aquatic conservation strategy for federal lands within the range of the Northern Spotted Owl. The resulting plan for federal lands was finalized in 1994 and is commonly referred to as the Northwest Forest Plan. At various times during the development of PL's Plan various parties have called for PL to adopt an aquatic strategy similar to that adopted as part of the Northwest Forest Plan (USDA 1994b). Although state/federal agencies never proposed adopting the aquatic strategy within the Northwest Forest Plan during the negotiation process of this Plan, the company did conduct a thorough review of the FEMAT report and the approach to aquatic conservation favored by the report's authors. This review identified numerous policy, scientific and economic considerations that would make implementation of a Northwest Forest Plan type conservation strategy inappropriate for PL's HCP. These considerations include:

- The Northwest Forest Plan was developed for application to federal lands. "The president then directed his Cabinet to craft a balanced, comprehensive and long-term policy for the management of over 24 million acres of <u>public</u> land… This decision <u>does not establish direction</u> or regulation <u>for</u> state, tribal, or <u>private lands</u>." (USDA 1994b, pp. 1-2, emphasis ours)

- The FEMAT team intended that the riparian buffer widths recommended in their analysis would serve as "interim" widths only, pending the outcome of watershed analysis. "Watershed analysis plays a key role in the Aquatic Conservation Strategy, ensuring that aquatic system protection is fitted to specific landscapes." (USDA 1993, pp. V-53). "We emphasize that the interim widths for Riparian Reserves are applied to all streams on National Forest and Bureau of Land Management lands within the range of the northern spotted owl until a watershed analysis can be completed… Analysis of site specific characteristics may warrant Riparian Reserves that are narrower or wider than the interim widths." (USDA 1993, pp. V-44).

- The Northwest Forest Plan no longer reflects the best available science. Published in 1993, and largely based on scientific data and literature compiled prior to 1992, FEMAT, the technical basis for the Northwest Forest Plan, was written using the best available science at the time. However, in the intervening years scores of new papers and datasets in the fields of fish-forest, and stream-forest interactions have become available. One example, the FEMAT authors state "We are aware of no reported field observations of microclimate in riparian zones…" The authors went on to use Chen 1991 as a reference for microclimate, even though this study examined microclimate in upslope areas. Since publication of the FEMAT report there have been at least two, more applicable, papers examining microclimate changes following harvest in or adjacent to riparian zones (Ledwith 1996, Brosofske et al. 1997). Both of these papers observed microclimatic effects that differed markedly from those reported in Chen (1991).

· Another example is FEMAT's curve for large woody debris recruitment (reproduced in Figure 5 as discussed earlier). Numerous other studies subsequently established that portions of buffers near streams are more important for LWD recruitment than areas located further away. This differs from FEMAT's curve which shows all portions of stream buffers being equally valuable for LWD recruitment (i.e., LWD recruitment is depicted as a linear rather than asymptotic relationship).

· The FEMAT team was trying to develop an aquatic strategy that would apply to all forests within the range of the northern spotted owl, that is, forests stretching from the US border with British Columbia to central California. However, PL's aquatic strategy is meant to apply only to its lands on the North Coast of California. This more limited geographic scope allows for a more specialized and focused approach to aquatic resource protection. For example, unlike other commercially important conifers, redwood trees generally do not die after harvest but stump sprout. The result is that the soil binding and stabilizing effects of roots are retained to a much greater degree following harvest than in other forest types.

· Even if all of the above considerations regarding the Northwest Forest Plan were not relevant, implementation of its Aquatic Conservation Strategy would still not be appropriate for application to PL's lands because it would result in severe economic impacts. Geographic Information System (GIS) modeling of the Northwest Forest Plan's riparian buffer recommendations (Scenario 1) showed that 56.8 percent of the company's ownership would fall inside riparian reserves and therefore be excluded from all commercial timber harvest (see Map 36 in Volume V). Many of the remaining portions of PL's lands, although technically available for harvest, would be so small or isolated (e.g., "slivers" and "islands") that they would not be economically feasible to harvest.

2. IMPLEMENTATION OF THE PLAN

PL is committed to utilizing management approaches and techniques that will provide for the long-term protection of fish populations and riparian dependent wildlife on its ownership. The Plan measures proposed by PL are based in part, on existing knowledge of what these fish populations require to grow and reproduce successfully, and on how management activities can be made consistent with the provision of such conditions. As noted, the proposed Plan measures are expected to have beneficial effects for most fish species on the ownership, and to have substantial beneficial effects for trout and salmon populations.

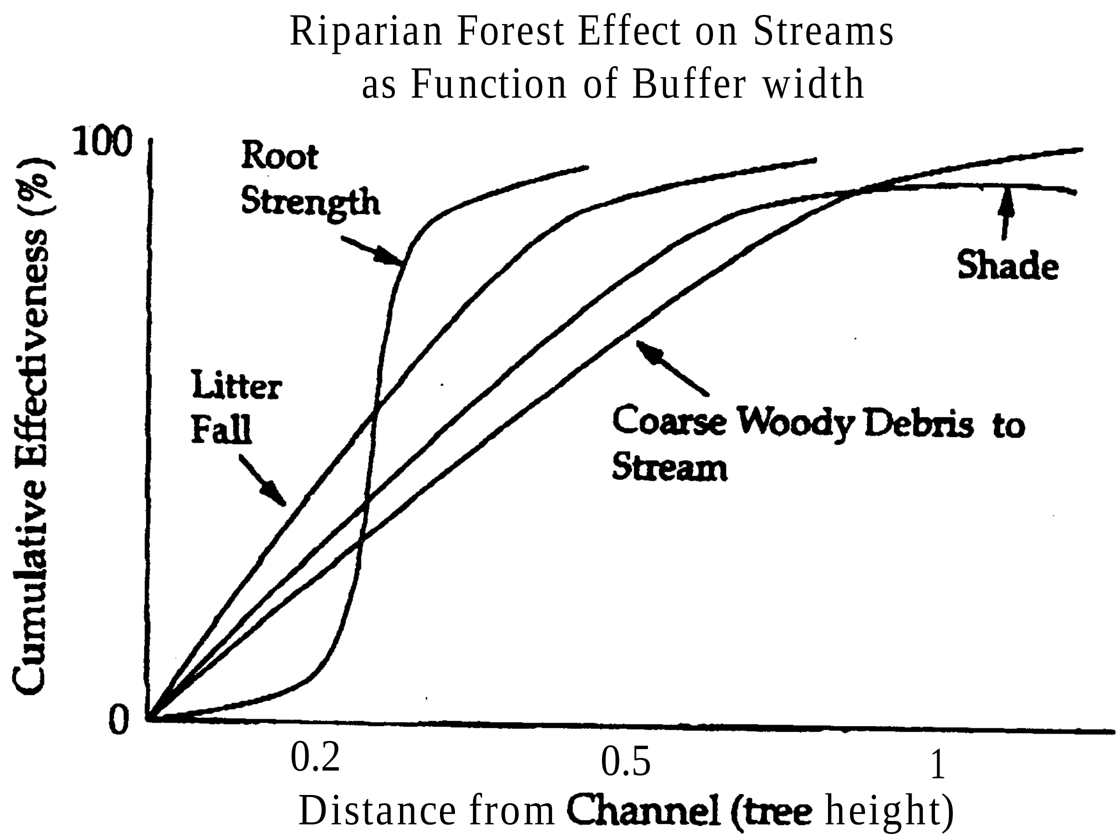


Figure 5 Generalized curves denoting the importance of several RMZ parameters and how they vary in relation to distance to the stream channel.

Although the proposed Plan measures incorporated scientifically supported approaches to watershed management, the inherent variability in natural systems and the imperfect status of watershed science as a whole make it impossible to develop a complete understanding of the long-term effects of the Plan on physical channel conditions and aquatic biota. Thus, the proposed Plan represents an important and significant step toward protecting important fish resources and associated aquatic ecosystems within PL's ownership. However, follow-up studies are needed to document the degree to which stream conditions and fish populations actually improve in the future.

Accordingly, PL has included within its HCP three measures designed to ensure the success of the Plan over the long-term. The first is a series of habitat condition goals that identify a desirable future state or set of conditions for streams on PL's lands. The second is a program of monitoring which is designed to provide information to determine whether habitat conditions are trending toward the desired future state. The third is an adaptive management program that will allow PL to alter its practices and strategies in the future, as needed, to ensure that aquatic resources on the ownership are protected. The relationship of these three measures is represented graphically in Figure 6. In addition, each of these programs is discussed in detail below.

2.1. HABITAT CONDITION GOALS

NMFS and cooperating agencies (e.g., USEPA, USFWS, state agencies) have developed a matrix that identifies criteria to assess "properly functioning habitat" conditions in streams along the north coast of California (Volume IV Part D Section 6). The matrix was developed by an interagency team based on a review of literature on desirable conditions for anadromous salmonids, particularly coho salmon, and on professional judgment. Certain elements of the matrix are summarized in Table 7. It is PL's view that although the matrix does a commendable job of trying to identify what constitutes "good" conditions for trout and salmon, there are technical concerns about the applicability to, and achievability of the matrix values to streams on PL's ownership. For example, most of the reviewed references were not based on studies conducted in redwood forests, and both contemporary data from unmanaged reference streams and historic studies of old growth redwood forests show that some of the goals are not achieved on the north coast even in the absence of logging and road building.

The matrix therefore is a good "starting point" for assessing the properly functioning conditions but that both additional research and monitoring on the property, in California, and in the Pacific coastal regions, and modification of the matrix to site specific conditions on the ownership will lead to changes in the matrix values (Figure 6). In addition, the matrix contains some habitat goals, such as tree retention standards along stream corridors, that have been superseded by the scientific research and negotiation conducted during work on PL's aquatic conservation strategy that has taken place subsequent to the matrix's publication date.

Figure 6 : Conceptual Outline of Plan Implementation

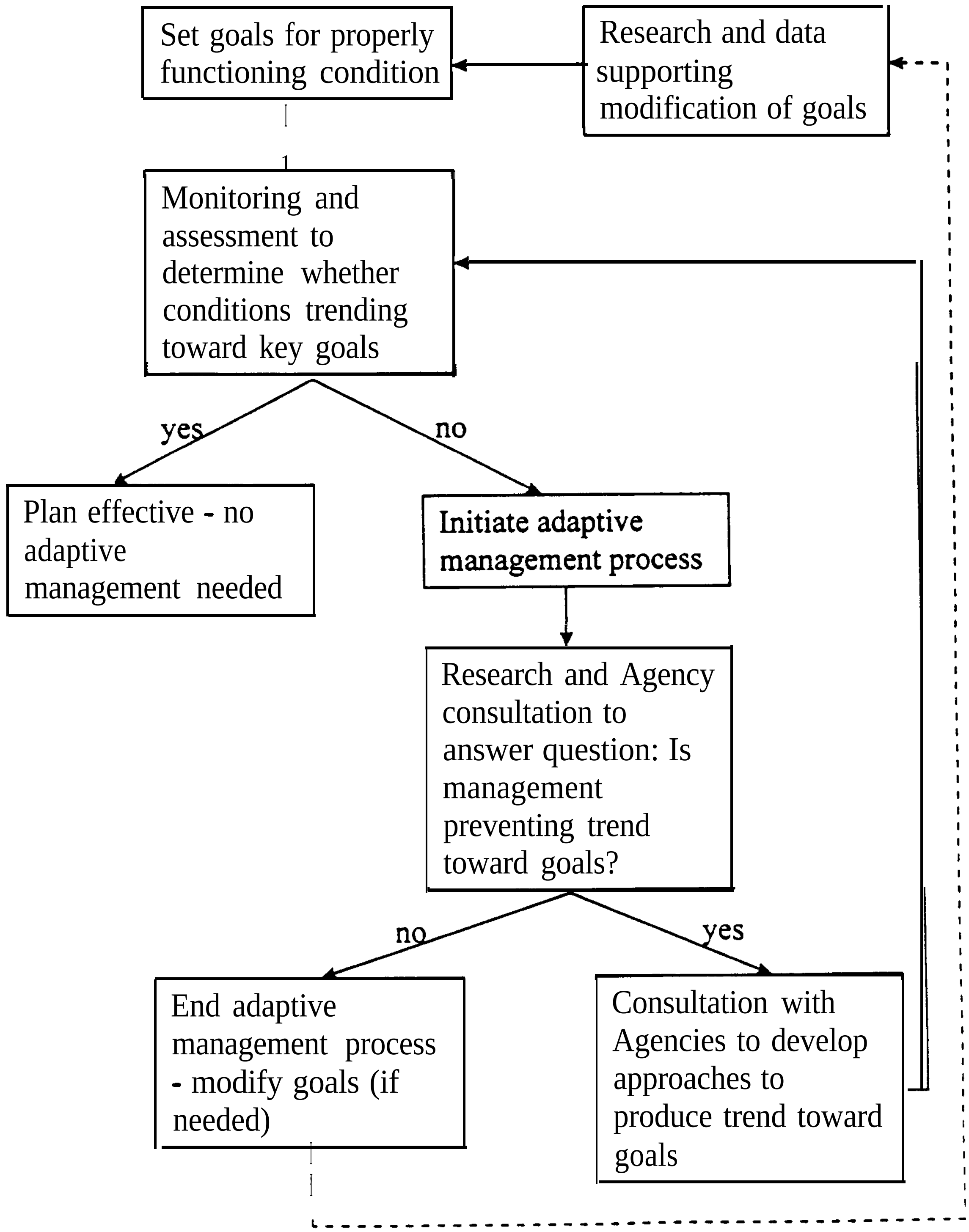


Table 7. Key goals for properly functioning condition identified by the Interagency Matrix

Biological Impact/Concern	Parameter	Target
Water Quality	***Temperature***	11.8-14.6 ^{o} C
	Sediment	
	1) % fine < 0.85 mm	1) Class I & II streams: < 11-16%
	2) pebble counts	2) D_{50} of 65-95 mm
	3) turbidity	3) no visible increase due to timber operations in Class I, II, or III streams
	4) % particles < 6.5 mm	4) < 20-25% in Class I & II Streams
Habitat Elements	***Large Woody Debris***	Channel Width (ft) / Mean Volume (cubic ft): 15 / 13 20 / 26 25 / 38 30 / 51 35 / 63 40 / 75 45 / 88 50 / 100 55 / 113 60 / 125 65 / 127
	Pool Frequency	
	1) Streams with gradient >3% and ave. width <10m	
	a) pool to pool spacing based on bfs widths	a) 1 pool per every 6 bankfull channel widths
	b) percent of stream surface area comprised of pool habitat	b) pool area >20% of the total stream surface area
	c) percent of number of pools associated with LWD	c) >90% of # of pools associated with LWD
	2) Streams with gradient <3% and ave. width < 19 m.	
	a) pool to pool spacing based on bfs widths	a) 1 pool per every 6 bfs channel widths
	b) percent of stream surface area comprised of pool habitat	b) pool area >25% of the total stream surface area
	c) percent of number of pools associated with LWD	c) >50% of # of pools associated with LWD
	Pool Quality	
	a) maximum depth	a) >3 ft maximum depth
	b) volume	b) V* = <20%
Riparian Buffers	***Water Temperatures***	
	1) Where high, mid-to-late summer water temp. regimes exist	
	a) overstory tree canopy closure	a) ave. of at least 85% overstory tree canopy closure
	Tree Abundance	
	1) Redwood dominated forest	1) 23.8 > 32 inches, 17.4 > 40 inches
	2) Douglas-fir dominated forest	2) 16.3 > 30 inches, 9 > 40 inches

bfs = bankfull stream

Despite the concerns and limits noted above both PL and the agencies agree that this HCP should consider the properly functioning conditions in the matrix. In addition, all parties agree that, if successful, the aquatic conservation strategy should lead to stream conditions that trend toward the key goals in the matrix. Thus, by agreement with the agencies: 1) the matrix is used here to identify a desirable future condition that the aquatic strategy will strive to achieve, and 2) the matrix does not constitute enforcement standards that must be achieved during the life of the plan.

The properly functioning conditions matrix identifies several biologically important, quantitative ("key") variables that can be used to assess the efficacy of the aquatic conservation strategy. These variables include:

- Fine sediments < 0.85 mm
- Median particle size (i.e., D_{50})
- Water temperature
- Canopy cover
- Pool abundance/size
- Large woody debris volume
- Tree abundance

As discussed in the monitoring section below, PL has committed to assess these key variables at study sites distributed across the ownership. Thus PL's monitoring program will provide the data to determine whether habitat conditions on the ownership trend toward the key properly functioning condition values identified in the agency matrix for these variables (Figure 6). PL's adaptive management program, in turn, provides for additional study/analysis and evaluation of the adequacy of the aquatic conservation measures in this HCP for circumstances where habitat conditions do not trend toward the key properly functioning conditions in the matrix (Figure 6). Adaptive management also provides for modification of the Plan measures, as needed, to ensure that habitat conditions trend toward the habitat goals (Figure 6).

2.2. MONITORING

As discussed in Section 1, PL's aquatic conservation strategy has several tiers or layers designed to ensure the protection of fish and riparian dependent wildlife on its lands. An important component of this multi-layered approach is monitoring. Monitoring, as used here, has three objectives: 1) to ensure that prescriptions included in either the interim or default aquatic conservation strategies, or those developed as part of the watershed analysis process are implemented in the field as specified; 2) to obtain a multi-year dataset to determine whether conditions in PL's streams and riparian zones are getting better, worse, or staying the same over time; and 3) to assess the effectiveness of the management approaches being used by PL to protect aquatic resources. Thus, PL's monitoring program represents a "double check" to make sure the company is doing what it said it would do (compliance or implementation monitoring), and that those actions actually provide the protection of aquatic resources they were meant to provide (effectiveness monitoring). Monitoring therefore greatly increases the certainty level that PL's aquatic conservation strategy will conserve fish and riparian dependent wildlife.

The ESA provides little guidance regarding what monitoring should include. The implementing regulations for Section 10 of the ESA do require that the Plan applicant specify "the steps (specialized equipment, methods of conducting activities or other means) that will be taken to monitor, minimize and mitigate" the impacts of taking [50 CFR Section 222.22(b) (5) (iii)]. However, even this is insufficient to guide development of a monitoring program.

Accordingly, PL used guidance in the HCP Handbook (USFWS 1996) to identify the requirements of its monitoring program. This guidance was combined with our previous monitoring work, with properly functioning goals developed by the relevant agencies (e.g., NMFS, USFWS, CDF&G), and with background research by PL staff, to develop the monitoring program being proposed here. The major elements of a required monitoring program (i.e., from the HCP Handbook) and monitoring studies PL will conduct to satisfy those requirements, are presented below:

2.2.1. Monitoring Program Objectives

As noted above, the monitoring program has three objectives: 1) compliance monitoring to ensure that prescriptions are implemented in the field as specified; 2) trends monitoring to determine the "trajectory" of habitat and populations on the ownership over time; and 3) effectiveness monitoring to ensure that management approaches being used by PL actually protect aquatic resources. These objectives can be posed as a series of questions, or, in some cases, scientific hypotheses, which, in turn, can guide specific data collection and analysis efforts. A partial list of such questions would include:

- How are prescriptions developed in the office or in collaboration with regulatory agencies being transmitted and explained to field personnel that are charged with implementing these prescriptions?
- Do completed harvest units have riparian buffers that conform to specifications in the submitted THPs?
- Are sediment related measures, including appropriate geologic review and road storm proofing, being implemented correctly?
- If aquatic mitigation measures specified in the THPs are not being correctly implemented in the field why not?
- How are critical habitat variables, such as pool depth, fine sediment levels, and canopy coverage, changing over time?
- Are stream channels exhibiting geomorphic changes that indicate sediment supplies to streams are increasing or decreasing?
- How is the abundance of adult and juvenile salmon and steelhead changing over time?

- Is blowdown in riparian buffers increasing large woody debris levels in streams?
- Is canopy coverage, and therefore shade, increasing or stable over time?
- Is there any long term trend in water temperatures at individual sites?
- Do watersheds with more intensive levels of management (e.g., more road miles or greater area with recent harvest history) show different patterns of habitat, geomorphic conditions, or fish populations than do those with less intensive management levels?
- Where landslides and road related failures from recent harvest areas result in sediment delivery to streams, what alternate management approaches, if any, could have prevented such delivery?
- Do PL's fisheries enhancement measures increase the amount of habitat available to or the population size of target populations compared to "control" reaches?

2.2.2. Focus of the Aquatic Monitoring Program

PL has several subject areas and biological species it is trying to include within its monitoring program. On the most basic level, PL is concerned with the fish, amphibian, and reptile species that depend upon streams and riparian zones for survival. Specifically, PL intends to use its monitoring program to determine the distribution and persistence of these species over time. More quantitative studies of the abundance of some of these species will also be conducted. For example, PL intends to conduct surveys of adult and juvenile salmon and steelhead in survey reaches on its ownership. Similarly, the abundance of habitat for key amphibian species, including tailed frogs and southern torrent salamanders, will be determined as part of larger studies to assess the effectiveness of PL's aquatic conservation strategy in providing habitat for riparian dependent wildlife.

PL's monitoring is not limited to species, or population level studies however. Indeed, one problem with monitoring of, for example, fish populations, is that they are prone to large year to year variations in both distribution and abundance, making any inference about the effect of PL's aquatic strategy difficult. Accordingly, the company has selected numerous aquatic habitat, geomorphic, and water quality variables for inclusion into its monitoring program. These environmental variables are meant to serve as surrogates in the assessment of PL's management impacts. In addition, as noted in section 2.1, the monitoring program is designed to provide data to determine whether conditions in PL's streams are trending toward the key properly functioning goals (Table 7, Figure 6). Where such trends are evident, it is likely that animal populations that depend upon these parameters will persist and/or recover.

2.2.3. Monitoring Variables and Data Collection Methods

The variables and techniques used for monitoring vary according to the type of monitoring activity. Details of the approaches PL is proposing to use for compliance monitoring, trends monitoring, and effectiveness monitoring are presented separately below:

Compliance Monitoring

PL currently has an internal auditing process whereby senior foresters within the company visit individual THP units or road work sites to ensure that all harvest/construction is conducted according to required specifications. PL will expand this program to include audits of the aquatic strategy/prescriptions. Specifically, a "checklist" will be filled out by PL for selected THPs. This checklist will the be same as that developed by PL and reviewed by CDF&G, NMFS, EPA, and the Regional Water Quality Board (RWQCB) for review of THPs by the California Dept. of Forestry. For those THPs subjected to such an audit, the checklist will be filled out by a Registered Professional Forester (RPF). The review will be conducted in the field based upon a site visit following completion of all ground work for the unit being investigated. Following completion of the checklist, it will be filed with CDF to confirm compliance with the specific prescriptions contained within the THP.

The specific number of THPs subjected to compliance monitoring will be determined by PL based upon the compliance "success rate." Initially, PL's goal is to conduct compliance audits on 5-10 percent of its THPs. If most or all of the reviewed THPs are found in compliance with prescriptions related to the aquatic conservation strategy, the number of audited THPs will be decreased. Conversely, if THPs are consistently found to be out of compliance with required prescriptions the number of audits will be increased until and unless improved implementation of required prescriptions can be documented.

PL's internal effort to document compliance with required prescriptions is only one aspect of the compliance monitoring that will be conducted. CDF has statutory authority to inspect PL's lands at any time for compliance with both the terms of specific THPs and any applicable laws. In addition, both CDF and other agencies (CDF&G and RWQCB) regularly inspect THPs. Thus, regardless of whether PL conducts compliance monitoring or not, a significant proportion of the company's THPs will be reviewed for adherence to applicable aquatic mitigations.

Trends Monitoring

PL already has a significant trends monitoring program in place on its lands. The company has installed 52 permanent sampling stations. At each station aquatic macroinvertebrates, fine sediments, substrate size and crown cover are measured. In addition, stream bed surveys and measurements of continuous temperature and large woody debris are conducted at a subset of the 52 stations. Details of the data collection/analysis efforts associated with this program are as follows (see also Volume II Part H for additional detail on PL's trends monitoring program):

- Aquatic macroinvertebrates are collected using methods in the California Stream Bioassessment Procedures prepared by Jim Harrington of CDF&G. This methodology involves sampling riffle habitats using a kick net. Collected invertebrates are preserved in the field. In the laboratory, the samples are subsampled, and the first 300 invertebrates identified to family, and, where possible, to genus. The samples are being identified by Lauck, Lee and Lauck Inc. Their results are used to calculate abundance (if less than 300), species richness (i.e., number of taxa), and the Simpson and Hilsenhoff diversity indices.

- Bulk sediment samples are being used to assess the percent of fine sediments (<0.85mm, and < 4.7mm) as an indicator of suitability for salmon spawning. PL is using the shovel sample technique as described in "Field Comparison of Three Devices Used to Sample Substrate in Small Streams" by Grost and Hubert, 1991. Collected samples are processed by CDF&G under contract to the company.

- Pebble counts are being used to calculate the median and 84th percentile sediment size (e.g., D_{50} and D_{84}). These sediment measures can be tracked over time to determine whether sediments in a stream are generally becoming coarser or finer, which relates to both sediment loading rates, and cumulative effects from management activities. Pebble counts are being collected using the method described in "Stream Reference Sites" by Harrelson et al. (1994).

- Measurements of water temperature over the summer are taken with continuous recording thermometers (Hobos or Stowaways). In addition, “point” measurements of temperature are taken during most other monitoring activities. Temperature data are used to calculate the maximum weekly average temperature (MWAT).

- Canopy cover (percent) is being used to identify areas that may be subject to higher thermal loading (e.g., from sunlight), and to document regrowth of riparian areas harvested in the past. Measurements are taken using a spherical densimeter using methods in Flosi and Reynolds (1996).

- Stream bed surveys are being conducted to determine how stream bed elevation is changing over time. This, in turn, is related to both sediment and LWD loading to streams. The methods for these surveys were developed by Dr. Bill Trush (Humboldt State Univ.) in cooperation with Simpson Timber Company. The method involves measuring the elevation of the channel thalweg using an engineers level and permanent benchmarks that can be used to compare results among survey periods. PL has also begun measuring channel cross sections using permanent benchmarks to track changes in channel width/shape over time.

- As part of the stream bed surveys, PL is measuring the abundance (i.e., percentage of channel length composed of pools), size and depth of pools within each study reach.

- Large woody debris is being measured because of its value in creating fish habitat, and to assess how much LWD recruits from riparian buffers along the stream. The diameter, length and location of all LWD pieces in the thalweg mapping segments is being recorded yearly.

Although not currently a part of PL's trends monitoring program, PL intends to collect data on fish abundance, turbidity, and discharge in the future. For fish, PL will establish a number of survey reaches across the ownership. Where possible these reaches will be selected to correspond to locations already being measured for the trends monitoring variables noted above. These survey reaches will be assessed twice yearly, during the summer (July-August), and again during the spawning season (for which the timing will vary from year to year). Summer surveys will be conducted using electrofishing, underwater observation, seining, angling, or other methods as appropriate, although preference will be given to quantitative methods if they are feasible. Spawner surveys will primarily be conducted using visual observation techniques, although trapping, seining or angling may be used to collect individual fish for measurement, identification, or radio tagging.

Turbidity measurements were recommended in a review of PL's monitoring program prepared for EPA by Randy Klein (Klein 1997). Although expensive compared to other sampling efforts used in PL' monitoring program, Klein's review suggested that turbidity could be an effective way to determine whether fine sediment inputs to streams are increasing or decreasing over time. The company proposes to establish one or two "pilot" turbidity monitoring stations. Results from this pilot program will be used to determine whether to continue or expand this program.

Historically, the USGS measured stream discharge at a series of stations on or adjacent to PL's land (e.g., Freshwater Creek, Larabee Creek). PL provided financial support for re-establishment of a gaging station on the Elk River, and intends to continue operation of this gage. The company is also considering establishment of gaging stations on Freshwater Creek, Yager Creek, and possibly in one or more of the smaller watersheds draining into the Eel River (e.g., Bear Creek). This monitoring effort would also be relatively expensive, so a final decision on whether to undertake this program will be made in the future based on the results of the Elk River "pilot."

PL recognizes that new data or scientific studies could result in future identification of other variables that would be valuable to monitor. It therefore, at its discretion, may add to the list of monitoring variables outlined here at a later date.

Klein (1997) discussed the distribution of monitoring sites on PL's lands, and suggested installation of additional monitoring sites. PL agrees that some portions of its lands, for example, the Elk River drainage, have relatively few monitoring sites relative to their land area. In part, this is a result of statistical chance, as many sites were chosen using randomization techniques. However, it is also true that the company made the decision to intensively survey the Freshwater and Lawrence creek basins to more accurately assess the potential impacts of its forest practices. PL intends to continue this intensive approach to sampling in these basins, especially given concerns over the potential for cumulative effects. However, the company also anticipates adding new monitoring sites to fill any "holes" in its coverage. Selection of specific sites will be included as part of the watershed analysis process the company will be conducting on its lands.

Effectiveness Monitoring

PL will monitor both instream and upslope conditions to assess the effectiveness of its aquatic conservation strategy. These effectiveness studies, in turn, will provide most of the impetus for the adaptive management component of the Plan.

PL's aquatic conservation strategy was explicitly designed to prevent three types of management related impacts to stream systems on its ownership: 1) loss of large woody debris recruitment from timber harvest in riparian zones and stream "cleaning," 2) increases in water temperature resulting from removal of shade producing trees along streams, and 3) increases in sediment inputs to watercourses from surface erosion and landslides that occur as a result of timber harvest or roads. Given that large wood, water temperatures, and sediment were primary concerns in developing the aquatic strategy, it follows that they would be key components of any analysis of the effectiveness of the strategy. Another key topic relates to the adequacy of the aquatic strategy in protecting habitat attributes important to amphibians. Finally, because maintaining the economic viability of PL is also a goal of the Plan, some assessment of the cost-benefit effectiveness of mitigation measures within the aquatic strategy needs to be conducted.

Determining the effectiveness of the aquatic strategy on LWD levels and recruitment potential requires two types of data: 1) a long-term dataset documenting the abundance of LWD in streams, and 2) data showing whether forest stands within riparian buffers develop increasing numbers of large trees over time. The first data type will be provided by the LWD abundance and volume data being collected as part of PL's trends monitoring program. Although it may take many decades before LWD levels in PL's streams increase significantly, the extreme restrictions on harvest in riparian zones, prohibition on stream cleaning, and blowdown of trees within the buffer strips should result in measurable increases in LWD over the next two decades. The second data type will be provided through the THP process itself. Many streamside areas on PL's lands currently do not have sufficient basal area or enough large trees to permit harvest under the harvest restrictions included in the interim aquatic strategy. Put another way, the entire width of many riparian buffers on PL's lands are currently "no cut" areas. If, in the future, PL documents through the THP process that these areas have developed sufficient basal area/large trees to permit harvest, then data documenting the effectiveness of the riparian prescriptions has been obtained.

The relationship between water temperatures and management activities in riparian zones is less clear than it is for LWD. For example, small streams, streams that have a northern or eastern aspect, and streams at higher elevations all tend to be cooler regardless of management activity than do larger streams, streams with western or southern exposures, or low elevation streams. Similarly, on PL's lands it appears that there is an east-west gradient in stream temperatures; streams nearer the coast are generally cooler than those further inland. For all these reasons it is not reasonable or practical to set a single effectiveness goal for streams on PL's ownership (e.g., "Stream temperatures should not exceed 16°C"). [Note: Until more location specific temperature goals can be developed, PL has agreed to utilize the properly functioning goals for temperature in the interagency matrix (Table 7)]. Monitoring of instream water temperatures will be conducted to see if recorded values show an increasing or decreasing trend over time. That is, within a given place, are temperatures generally increasing, decreasing, or staying about the same. One problem with this approach is that air temperatures can strongly affect water temperatures. So, for example, a hot summer following several cool ones could result in an erroneous conclusion that temperatures are increasing over time. Thus, water temperature data must be collected for at least 5 years before any trend could be detected. Regardless, PL intends to use water temperatures as an effectiveness monitoring tool.

Determining the effectiveness of the aquatic strategy for temperature can also be done by determining whether canopy closure over streams increases over time. PL's monitoring trends of canopy closure values can be used to determine whether this occurs.

Sediment is perhaps the most difficult variable to conduct effectiveness monitoring on. This is so because of:

- The high natural rate of sediment inputs to streams on PL's ownership. This makes it difficult to determine how much sediment resulted from management activities, and how much would have entered streams regardless of management.

- The temporal variability in the rate of landslides and road failures. Most landslides and road related failures occur during very large storms. Thus it is possible to have a string of years with no large storms, and correspondingly low mass wasting rates, followed by successive years with large storms and correspondingly high sediment production.

- The question of deliverability. Not all sediment that erodes from roads, or that slides down hillslopes is actually delivered to streams. The riparian buffers in PL's aquatic strategy are likely to increase the interception of sediment, changing delivery rates relative to those seen under past management practices.

- The variable impacts of sediment on stream channels. Some stream channels, for example those with higher gradient and narrow valley walls, will be much less sensitive to sediment inputs than others. Thus, the same amount of sediment entering a stream can have very different effects on channel conditions, and therefore stream habitat for aquatic species, depending on geomorphic factors in the channels themselves.

- Streams and floodplains can store sediment from past episodes of sediment delivery. Thus, there may be a significant "lag time" between implementation of the sediment control measures in the aquatic strategy and measurable reductions in instream sediment levels.

- Unlike LWD and temperature where, basically, a single conservation strategy, retention of streamside trees, is the mechanism for “fixing” problems, PL’s aquatic conservation strategy has numerous, often overlapping approaches to controlling sediment. Thus, if sediment levels in streams decrease, it may be very difficult to determine which mitigation measures, or combination of measures, actually resulted in the decrease.

Given this uncertainty, PL expects that its approach to determining the effectiveness of sediment control measures will be modified over time as new data and scientific results become available. In the interim, trends monitoring will provide data on instream sediment levels, channel morphology, stream bed aggradation/degradation, and biological metrics sensitive to sediment (e.g., invertebrate diversity). Increasing sediment levels, sediment levels that do not trend toward the key properly functioning goals in the interagency matrix (Table 7), or direct sediment impacts on stream biota as measured by these variables, could all be indicative that sediment is still a “problem,” and that the aquatic strategy may not be adequately addressing sediment inputs.

Assessment of the effectiveness of the sediment control measures will necessarily require monitoring of sediment production rates from roads and hillslopes. This has the added advantage that any shortcomings in PL’s sediment control measures may be detected earlier than if the company depended only on instream conditions, and, thus, alternate management approaches can be instituted before impacts to aquatic resources occur. As part of the watershed analysis PL will be conducting sediment source analyses for all of its lands. These studies will provide baseline data on the number, location, and size of existing sediment sources on the ownership. In addition, these studies may provide a sediment budget identifying the amount of sediment being delivered to streams from different sources. Following these baseline studies, PL will continue to inventory new landslides and road related failures as they occur. Within 5 years of completion of the baseline sediment study, a follow up study will be conducted to determine how many slides have occurred in the interim, their relationship to management activities, and how the rate of management related landslides compares to the rate in the baseline period. These follow up studies will be completed at five year intervals. PL expects that this type of upslope trends monitoring will provide the necessary information for determining how the aquatic conservation strategy has affected sediment delivery to streams. In addition, because the follow up studies will examine the relationship between management and sediment production, their results should be able to provide guidance on how to modify management activities, if necessary, to reduce sediment production.

Monitoring the effects of PL’s aquatic strategy on amphibians is necessary to ensure that the habitat needs of these species are provided for. Amphibians such as tailed frogs, southern torrent salamanders, and foothill yellow legged frogs are generally thought to require many of the same habitat attributes as fish including cool water temperatures, low fine sediment levels, and large woody debris, including debris in riparian areas. Thus, effectiveness monitoring for temperature, sediment and large wood being conducted for fish should also provide information on the adequacy of the aquatic strategy for amphibian species as well. However, because some of these amphibians can be found in streams that do not contain fish, effectiveness studies will need to be extended upstream to Class II streams. As with sediment, PL expects that its amphibian monitoring efforts will be modified over time as new data and scientific results become available. For example, PL has agreed to work with the USFWS and CDF&G to develop an amphibian habitat module for use in our watershed analysis work. As this module is applied to lands across PL's ownership additional information that may bear on an effectiveness monitoring program may become available.

Cost-benefit effectiveness studies are needed to determine whether protective measures being implemented by PL in the field produce benefits proportional to their costs to the company. Similarly, such studies could identify alternate mitigation approaches that continue to protect resources but at lower costs to the company. At present, PL is generally able to identify the costs of specific mitigation measures with greater ease and certainty than it can identify the benefits of these measures to fish and wildlife. As new data on the biological benefits of mitigations within the aquatic conservation strategy is obtained, it may be possible for the company to more accurately assess cost/benefit ratios.

2.2.4. Cumulative Effects Analysis

Cumulative effects are defined as "[t]hose effects on the environment that result from the incremental effect of the action when added to the past, present, and reasonably foreseeable future actions…" (USDA 1993). Analysis of the cumulative effects of PL's activities on aquatic resources should focus on the same "fluxes" mentioned previously: large woody debris, canopy/temperature, and sediment. Thus, cumulative effects can be expressed as a question: What are the effects of PL's current and future proposed actions (e.g., timber harvest and road building) on LWD and sediment levels in streams, and on the canopy closure and water temperatures present?

An ideal cumulative effects analysis would be able to quantify the aquatic impact of each incremental amount of management activity. Such an analysis would, for example, identify the increase in fine sediments in streams associated with each acre of forest harvested. However, despite extensive scientific research, no cumulative effects analysis to date is able to provide this type of quantification. The reasons for this vary, but include:

- Streams are dynamic systems that show high variability in conditions over time. For example, stream morphology or canopy closure can literally change in hours in response to large floods. Similarly, water temperatures in streams are higher during hot summers than during cooler ones. If "background" values are rising and falling over time it is very difficult to measure the incremental effect of management on conditions in streams.

- The impacts of management are themselves highly variable in time. For example, during a period of drought years, erosion and mass wasting from managed areas may be quite low compared to years with high rainfall.

- The science to differentiate between management caused landslides on hillslopes, and those that would occur naturally is poorly developed. As a consequence, it is usually possible to show that managed areas have a higher overall rate of landsliding, but not possible to say whether an individual failure was management related (Pyles et al. 1998).
- Because landslides vary dramatically in size and in the amount of sediment they deliver to streams, the inability to say whether an individual landslide was caused by management makes it very difficult to assess how much sediment that is delivered to streams is because of timber harvest.
- There can be a large "lag" time between when an event or activity takes place and when the effects of that activity become detectable. A natural example is large storm events that produce landslides. Because sediment from the landslides can be stored in riparian areas and in the stream channel it may not be possible to detect the downstream effects of the landslides until after channel migration or flood events result in transport of those sediments.

In addition to these generic difficulties in conducting a quantitative cumulative effects analysis, PL has two additional problems specific to its ownership. First, PL's ownership is located in a geologically variable, and unstable area. Thus, different slopes, parent geologies, and soil types result in highly variable rates of erosion and mass wasting on the ownership. It seems likely that the impacts of management on erosion/mass wasting would therefore also be highly variable. The second problem relates to the impacts of past practices. PL's ownership contains hundreds of "Humboldt crossings" and many miles of old skid trails and railroad grades. Humboldt crossings involved filling creeks and hollows with cull logs, then filling over the logs with sediment. As the logs in these crossings rot out, the sediment fill becomes increasingly prone to erosion or mass failure. Similarly, skid roads, which were historically built to drag logs to collection points, and railroad grades used to transport logs, were often built on steep ground, and over unstable areas. Collectively, Humboldt crossings and unstable portions of skid trails and railroad grades represent a "legacy" of past management that is likely to contribute sediment to streams on the ownership for decades. Humboldt crossings, in particular, are now getting old enough that they are beginning to fail, leading to sediment delivery. The company is actively working to locate and fix Humboldt crossings, skid trails, and railroad grades, and will maintain or expand this effort in the future. However, sediment from these legacy problems will continue to move down to streams, further increasing the difficulty of assessing the impacts of current and future management on sediment levels.

Given these, and other difficulties, PL does not believe any cumulative effects assessment methodology is available that can identify the incremental impact of a given amount of management activity (e.g., acres harvested or road miles constructed). Accordingly, the company proposes to follow the widely used practice of trends monitoring to assess whether cumulative effects are present. PL intends to use its in-stream monitoring data to determine whether conditions with respect to LWD, canopy/temperature, or sediment are getting worse over time.

If conditions are stable, or improve, then current practices are not resulting in changes in stream conditions that will increase any negative impact to aquatic resources over time. However, if conditions become worse, then further action is necessary to identify why the trajectory is negative, and what, if anything, can be done to improve things. PL proposes to use the trends monitoring data from streams as follows:

- Fine sediment data (percent < 0.84mm), and bed elevation data from the channel surveys for each station will be plotted over time. If a significant positive regression between these variables and time is exhibited at any station, the company will hire a fluvial geomorphologist to examine the site and develop a report identifying whether the increase appears to be due to local or temporary conditions. If the increases cannot be attributed to local or temporary conditions, PL will initiate consultation with the agencies as outlined below.

- Similarly, water temperature data for each station will be compared over time. Initially, a statistical analysis (e.g., ANOVA followed by alpha adjusted multiple comparison t-tests) will be conducted on average daily, and daily maximum stream temperatures for the summer months. A positive statistical result (i.e., temperature increase or increases over time are significant) will lead to an analysis of air temperature data for the years exhibiting significant differences. Air temperature data are available for both Scotia and Eureka. By comparing the differences in air temperatures, a “correction factor” will be developed that will allow the observed water temperatures to be adjusted for differences in thermal loading. Finally, the corrected water temperature data will again be statistically evaluated. If temperatures still demonstrate a significant increase over time the company will consult with the agencies as outlined below.

- As outlined under trends monitoring, PL will assess both spawner and juvenile fish abundance over time. If a significant negative regression in either of these variables over time is exhibited, the company will consult with the agencies as outlined below.

- PL will compare the delivered sediment volume of new landslides originating in three management types: 1) areas subjected to the new rules outlined in this Plan, 2) other areas that have been harvested in the last 15 years, and 3) areas that have not been harvested in the last 15 years. If the delivered sediment volume from areas of type 1 significantly exceeds that in types 2 or 3, the company will consult with the agencies as outlined below. All comparisons will be done using geographically and geologically similar areas to the extent possible.

Under any of the “triggers” outlined above leading to consultation, PL will contact NMFS, EPA, CDF&G, CDF, and RWQCB to arrange for development of a technical evaluation group. As discussed previously, PL has also agreed to undertake agency consultations if stream conditions do not trend toward key properly functioning goals identified by the agencies (Table 7). The technical evaluation group will convene to review and discuss the results leading to the consultation. Initially the group is expected to outline data collection and analysis efforts that the company should undertake to clarify whether the observed result is due to management activities, and if so, what, if anything, can be done to reduce or eliminate the cumulative effect. Subsequent to these additional data collection and analysis efforts, the technical evaluation group is expected to reconvene to determine appropriate actions to be taken by the company, and on any additional monitoring, analysis, or reporting requirements. Follow up meetings will continue, as needed, until either the conditions leading to consultation no longer exist, or until all parties agree that the company has addressed any management related effects to the maximum extent practicable.

2.3. ADAPTIVE MANAGEMENT

Adaptive management is a technique that uses scientific information to help formulate management strategies. Adaptive management approaches have two distinguishing characteristics:

> The first essential characteristic of adaptive management is that a direct feedback loop exists between science and management. This allows for management and policy decisions to be modified in light of new scientific information. The second essential characteristic of adaptive management is that management is an experiment. An adaptive approach emphasizes that resource management itself is an important source of experiments on the natural system (Fluharty and Lee 1988). It is the combination of these two characteristics that distinguishes adaptive management from either traditional science or incremental "learning as you go" (from Halbert 1993).

Adaptive management is an increasingly popular approach in natural resource management because it simplifies decision making when scientific uncertainty is present. For example, the Bonneville Power Administration (BPA) has used adaptive management for over ten years to make decisions about how to restore salmon populations on the Columbia River (ISG 1996). Many recent HCPs similarly depend upon adaptive management to ensure the long-term protection of species (e.g., Plum Creek 1996; WADNR 1996).

The adaptive management process, as proposed by PL, contains two steps. In the first, the effectiveness of current management methods for protecting and restoring stream conditions and fish populations is determined. As a second and follow-up response step, new management approaches are developed and implemented as needed to address shortcomings in current management methods.

As discussed in this Subsection 2.2, trends monitoring is the primary method used to assess the effectiveness of existing management methods and approaches. If the measures proposed and subsequently implemented in the Plan are effective, then degredation of stream habitat, water quality, and ultimately fish populations should not occur and many variables should show improvements over time. Thus, the effectiveness of the Plan can be assessed by examining conditions in the stream environments on PL's property. If good habitat values are maintained, and impaired values trend toward the key properly functioning goals, then the measures implemented under the Plan would be deemed successful and major changes to the Plan would not be warranted (Figure 6). Conversely, changes in management methods would be indicated if conditions degrade or do not trend toward key properly functioning goals. The information used to make these determinations must encompass a sufficiently long sampling period and be representative of enough sites to ensure that monitoring data are accurately depicting conditions on the ownership, and not local or short-term variability.

Subsection 2.2 provides a detailed discussion of the monitoring and cumulative effects assessments that PL is proposing as part of this Plan. This discussion included “triggers” that would lead to agency consultation regarding the adequacy of the HCP measures. In addition PL has agreed to initiate consultations if habitat conditions do not trend toward the key properly functioning goals. These triggers, the consultations to determine appropriate corrective actions, and the monitoring process, represent the basis of the adaptive management process for the aquatic conservation strategy being proposed by PL (Figure 6).

PL intends to conduct a research program on its lands in conjunction with the monitoring studies identified in this Subsection 2.2. While the research goals of this program are still being developed, the overall approach will emphasize formal hypothesis testing. Example topics include:

- The effectiveness of instream habitat improvements in attracting juvenile coho salmon and steelhead trout.
- Modification of PL’s hatchery program to emphasize releases of fry, including effectiveness studies.
- The distribution and habitat needs of amphibians on the ownership.
- The relationship between LWD levels and coho abundance.
- Development of strategies to enhance LWD abundance in the near term while riparian vegetation develops.

Results of these or other research programs will also be used to determine how best to provide for the needs of aquatic resources on PL’s lands. However, such information is most likely to identify “what else can be done,” rather than “what’s wrong with” the approaches included within the Plan.

2.4 ADDITIONAL MODIFICATIONS TO THE AQUATIC STRATEGY

Just as adaptive management may indicate that additional prescriptions are necessary to protect aquatic resources, it may also indicate that some of the prescriptions contained in this aquatic strategy are unnecessarily restrictive of PALCO's ability to manage its lands without providing any significant benefit to the aquatic species managed and conserved by this HCP. In such cases the plan shall be subject to change. The trigger for identifying when such changes will be considered shall be the approval by the agencies of a plan, whether through an HCP process, a biological opinion process or any other process, which imposes on a private timberland owner in the Southern Oregon/Northern California Coast ESU for coho salmon prescriptions that are less restrictive than those imposed on PALCO.

Upon the approval of such a plan, PALCO may request a review to determine for which of PALCO's streams the prescriptions applied to another landowner may now be applied purusant to this plan. In addition, if the Agencies have revised their criteria of properly functioning habitat, PALCO may request a minor modification to this HCP to apply the new criteria to this HCP and a new set of default prescriptions for this HCP in light of the new criteria.

Alternatively, upon the completion of a watershed analysis on any of PALCO's watersheds, if a dispute arises regarding the applicable prescriptions for that watershed, PALCO may request a comparison between the proposed prescriptions for its watershed and the prescriptions imposed on any other private landowner's watershed within the Southern Oregon/Northern California Coast ESU for coho salmon. If the Agencies have determined that the prescriptions for another landowner's watershed will lead to properly functioning conditions, then PALCO may elect either to have the default prescriptions under this HCP apply, or the other landowner's prescriptions apply.

In any of the cases above, (i.e., PL requests a review, agency definitions for properly functioning conditions change, or in cases of dispute over the prescriptions derived from watershed analysis), the Agencies will rely on the best available commercial and scientific data, including the administrative record related to the plan applying to the other landowner to determine whether changes in prescriptions applied to PL’s lands are warranted. The criteria that the Agencies will use in determining whether to apply the other landowner's watershed prescriptions on any of PALCO's watersheds include: the degree of overlap between the aquatic species found in the two watersheds, soil types, topography, distance from the Pacific Ocean, and the amount of rainfall each watershed receives. In the event the Agencies decide not to change PALCO's riparian prescription, PALCO may seek review of such Agency decision through the ADR process set forth in the Implementation Agreement or judicially.

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